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evoted to Measurement and Control Problems

ol. 3. No. 6 Pittsburgh, Pa. June, 1930

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General Electric Watthour Meter
Pattern 574 Voltohmmeter
A. P. C. Opacimeter
Graphic Instruments
Self-Contained Radio Ohmmeter
New Micro-Indicator Support
Datagraph
Optical Bevel Protractor
Optical Centering Level
Special Design Manometer

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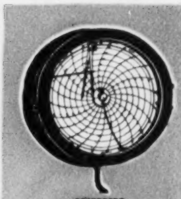

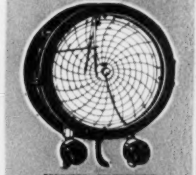
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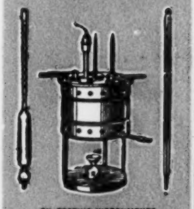
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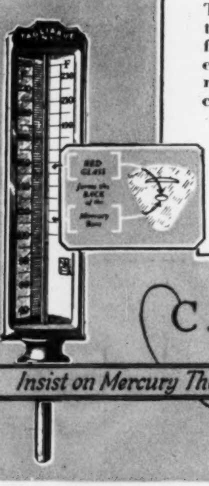
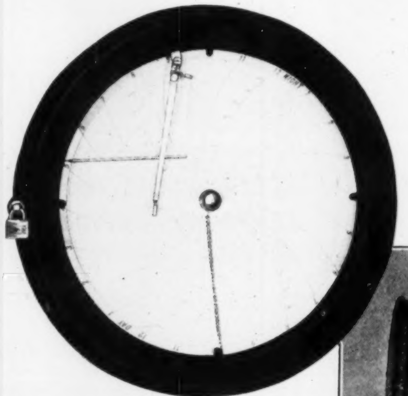
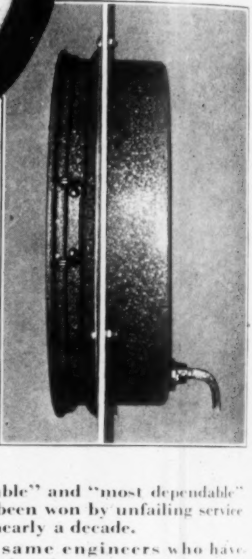

RED GLASS forms the BACK of the Mercury Bore





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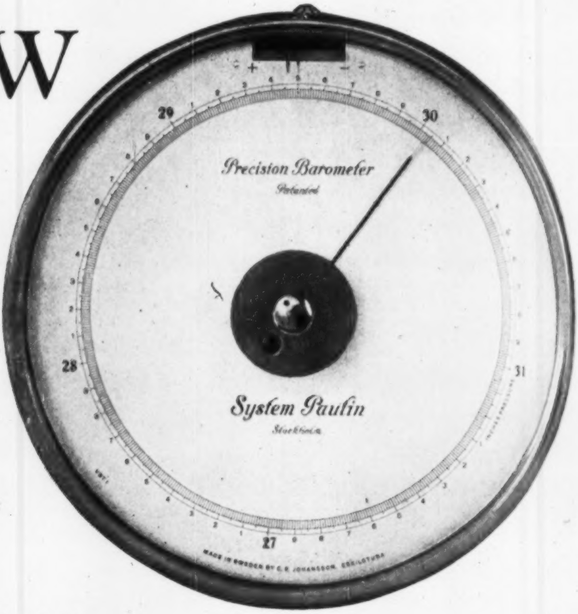
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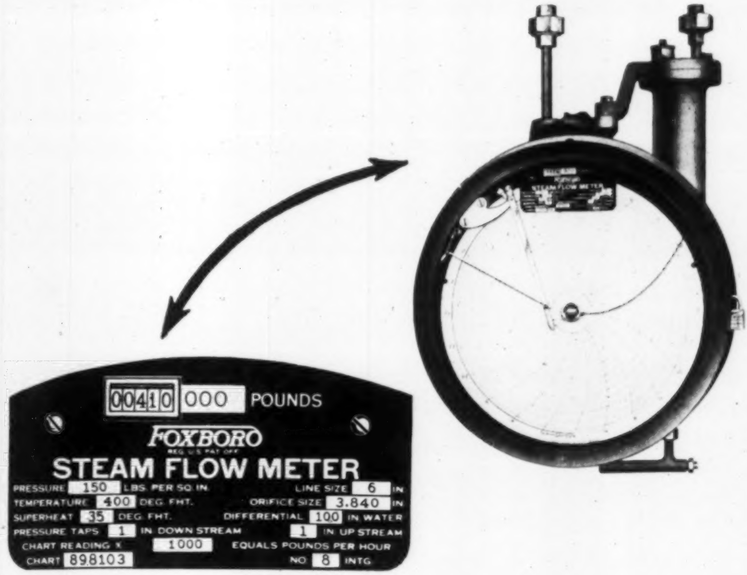
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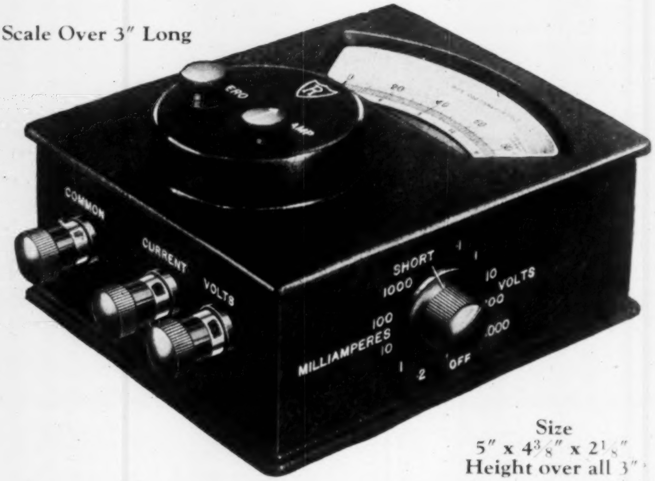

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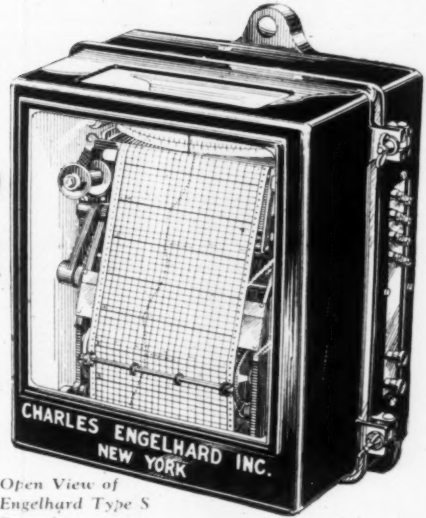

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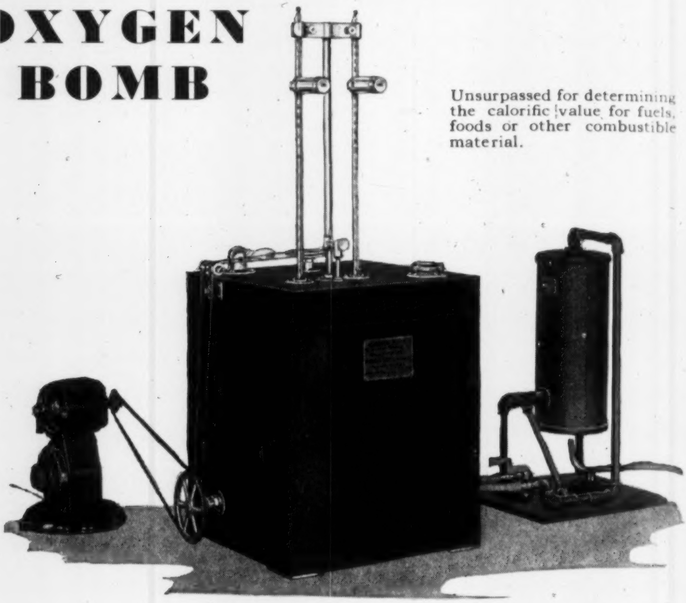

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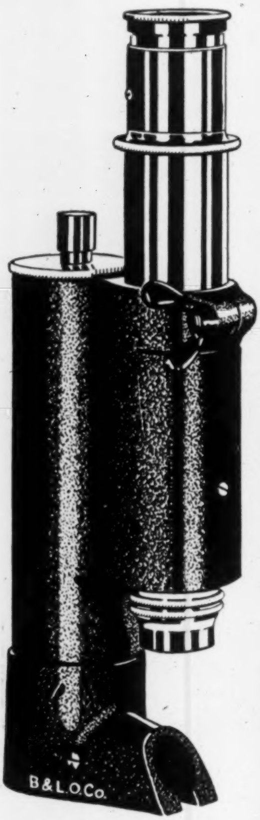

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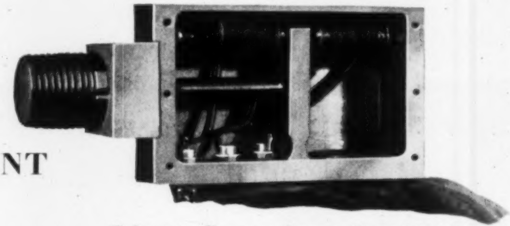

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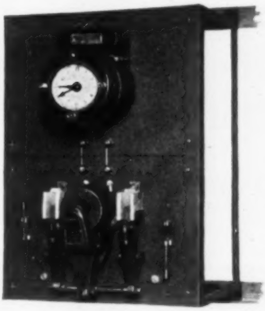

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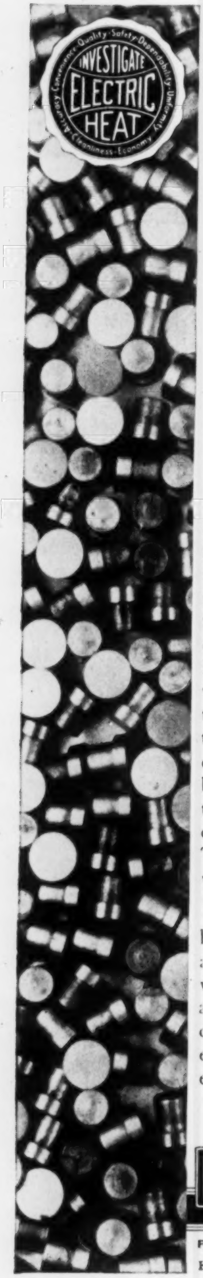
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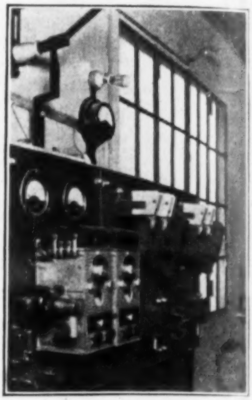
An interesting application of automatic pyrometer control

This electrically heated sheet metal annealing furnace is under the absolute control of the Wilson-Maeulen temperature controllers shown on the panel at the right.



WILSON-MAEULEN Co
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INSTRUMENTS
INDUSTRIAL — SCIENTIFIC
(Reg. U. S. Pat. Off.)

Vol. 3, No. 6 JUNE, 1930 Pittsburgh, Pa.

To Our Readers

SOME of our readers, without reading the editorial in our May issue, assumed that INSTRUMENTS was carrying on propaganda for the English System of weights and measures, due to the fact that we printed the article entitled "The Practical Difficulties of Introducing the Metric System into the United States."

Nothing could be further from the truth, as will be seen from our May editorial in which we point out the danger of compulsory legislation on the Metric System, especially when we consider the experience we are passing through with prohibition. Further, we urge that careful thought be devoted to this question and also urge engineers and others concerned with measurement to take an active interest in this question.

The editor believes that very much more can be accomplished by "education" than by "legislation."

The article by Mr. Bullock* in the May issue of INSTRUMENTS presents one side of the story, the article by Mr. Richards** in this issue the other side. The editor has expressed no opinion, which might favor either side.

INSTRUMENTS will make an effort to determine the opinions of all those who should be interested in this subject. Therefore, beginning in July, ballots will be sent out to sound out the sentiment of the engineers and scientists whose names appear on our lists.

When you receive this ballot, we hope that you will fill it out and return it to us promptly. Do not take a passive attitude, let us have your opinion.

While the statement should be oviously unnecessary, we might add that the editor will conduct this poll in an unprejudiced manner and will publish the figures no matter what they reveal.

---

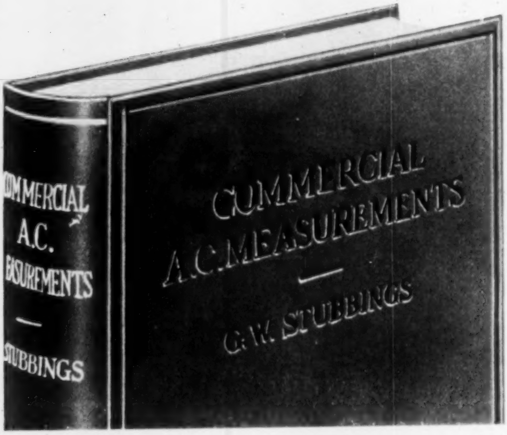
*Secretary, American Institute of Weights and Measures.
**Treasurer, Metric Association.

INSTRUMENTS
Book - of - the - Month

Commercial A.C. Measurements

By

G. W. Stubbings, B. Sc., F. Inst. P., A. M. I. E. E.



Price Postpaid $5.00

341 Pages

The book deals with the theory of a. c. measurements and while somewhat technical is so well written that it will be easily understood by the average engineer.

At the end of each chapter a reference is made to articles that have appeared on the subject discussed. Practically all references, however, refer to British publications. This of course, is to be expected. The papers referred to are all well selected.

The arrangement of the book is good and the subject well covered, discussing in addition to the instruments themselves, and their use, also accessory apparatus, such as instrument transformers, etc.

The reviewer is certain that a great deal can be learned from this book, and recommends it highly to engineers who are called upon to make a. c. measurements. It can also be recommended to students who are studying a. c. measurements as the subject is presented in a very clear cut and precise manner. The reviewer does not hesitate recommending it to the readers of INSTRUMENTS as it covers the subject better than any other book, which has come to his attention.—E. S. Lincoln.

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The Metric Question

Frederic L. Roberts*

MODERN industry rests upon scientific foundations. Perhaps the most essential of these is measurement. The keynote of modern industry is precise measurement. Upon this rests the possibility of both quantity production and quality production.

Protagoras begins one of his books by saying "Man is the measure of all things." Surely man is the measurer, and measurement his master art. The Sanskrit root in the word "Man" means both "mind" and "measure." Measurement is not merely an art, it runs through all arts, sciences, industries—it is the master art.

Measurement is a pioneer. Early history writ on trees marked by notches the height of flood and the passing days. Man measured the earth, geometry; the turning shadows of the day, chronometry; the stars and their motions, astronomy; the seasonal migrations of the sun, chronology.

Through measures alchemy was transmuted into chemistry, magic into physics; and astrology into astronomy. Measures bring new eras. The theodolite precedes the railway; the micrometer ushers in the machine tool age; the pyrometer, a new era in metals; the kymograph, a new psychology; the X-ray, a new knowledge of atoms.

The great step most urgently needed in industry and in commerce is a single standard of measurement. Such a standard has been attained in respect to the measurement of time, latitude and longitude, angle and circle division, our system of numbers, etc., etc. The United States is ready to take the next step!

Looking backward we trace the steady development of what we might term "value guides." Since early cave man days, with the beginning of the practice of bartering came the development of standard units. At first, those things nearest at hand were accepted—the foot, arm (we have the cubit in the Bible which is supposed to be the length of the forearm and hand, i.e., from elbow to finger tip.) and so on. Then such things as the "stone," and "barleycorn" were adapted to use.

As civilization developed, the units and standards became more definite; and soon it became a function of the governing power not only to determine and maintain them, but to enforce their proper use and prevent fraud. The rulers assigned this work to the priests and scientists or wise men of the tribe. And so since early times there has been involved a certain spirit of cooperation for mutual advantage and an exercise of authority to secure not only honesty and equity, but more, important perhaps, uniformity.

Tribes merged, races were built up, wars were waged, nations came into being. Each and all held to their hodge-podge weights and measures until recognizing the need for greater intercourse they opened their markets to each other—and with this came the realization of a need and the development of standardization.

This standardization has advanced immeasurably in the past 100 years. It's progress would be greatly accelerated if the people of the United States and Great Britain were to recognize the ultimate trend and accept the universal language of quantity, intelligible to humankind and a potent factor in commercial development.

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*Treasurer, American Metric Association.

That we hold to our inheritance of archaic weights and measures despite our own logic and reasoning, and remain aloof from the other nations of the world in this one aspect, hardly seems in line with our preachments of good will and international fellowship. That we have advanced to a point leading the nations of the world has not been because of our conglomerate system of weights and measures, but in spite of it!

When one realizes that it took Arabic numerals 180 years to supplant the old Roman numerals, I, X, L, V, C, etc., the advance of metric weights and measures is remarkable. Since 1790 all of the nations of the world but two have made the change and since 1920 alone we find that some 339,509,000 people of the world have accepted the metric system for general use.

However, what concerns us more is the advancing use of meters, liters, and grams in this, our own country. Arthur E. Kennelly, of Harvard University, at the joint meetings of the Metric Association and the American Association for the Advancement of Science held in Des Moines, on December 30th of last year graphically illustrated the advance of the metric system through a simple statement of fact, a fact which we all have observed but to which we perhaps neglected to give much thought. "Looking back during the last twenty years into every-day American literature comprising, say, newspapers, journals, and magazines, one cannot fail to be struck by the increased general use of the international metric system. Today, the frequent use of the metric terms has so familiarized the American public with these international units that they now pass into current newspaper and magazine text without any translation, explanation or comment."

Perhaps it would be interesting to know that the eye-glasses one wears, the watch one carries, the magneto one has in his automobile, the ball bearings that make for smooth riding, and countless other items are entirely metric.

Samuel W. Stratton, when head of the Bureau of Standards, in a report made on the metric system which later was offered in testimony on behalf of a Metric Bill before Congress, named more than a dozen of the leading industrial concerns of this country that were using metric weights and measures to a large extend if not exclusively.

Certain objections have been suggested, among which five may be cited. Inasmuch as it is admitted that the metric system is far superior as a system than our present system, these objections relate mainly to cost and anticipated difficulty and confusion.

1. It is said that if the metric system is used, it would mean two systems instead of one. The fact that two systems are already in legal use in this country answers this objection. The time has passed to raise this point. The law of 1866, making the metric system legal for all purposes has resulted in a greatly increased use by manufacturers, many of whom carry lines of products in both systems, one for domestic, the other for export business. It may be added that the use of the metric system for domestic trade is steadily increasing.

2. The cost is a second objection. The fact that all firms that do any export work carry metric-sized or metric-marked products indicated that it is profitable to do so. Some of the most conservative firms have for many years carried such lines of metric products side by side with those based on

the customary units. The experience is that the prices of such metric products are no higher than the corresponding American sized products, especially measuring tools. A casual examination of tool catalogues is convincing on this point. An experience such as the manufacture of French locomotives in a Philadelphia locomotive works using metric measures for this purpose shows how by intelligent handling any anticipated expense can be minimized or even avoided.

3. It is claimed also that much of existing information now in the workman's mind in customary units would be less useful when working in the metric system. The sufficient answer to this is that approximate equivalents, easily learned, permit ready translation during the short period needed to acquire the new knowledge. However, modern technical data cover too large a field and handbooks and tables are too widespread to require that large amounts of numerical data should be memorized. It is in fact a question whether this is not to some extent a harmful practice, since numerical data are subject to change as more exact values are obtained by research, the fact that even engineering handbooks quickly become out of date on account of such changes is conclusive on this point. However, any loss from this cause would be more than compensated by the gain in availability of foreign technical data which are now a sealed book to those unacquainted with the metric system.

4. A common fallacy is that standard sizes now in customary units would have to be changed. Where a size is the most efficient size, it need not be changed. Where it is not the most efficient size, it should be changed whether we change our system of measures or not. Any efficient size may be retained and can be expressed equally well in metric or custom units or in both, as if often done. A vital consideration, however, is that in order to be permanent, standardization must be international, and since the large majority of the countries are using the metric system, and this is the only international system, world standardization can best be done in metric units.

5. Some have felt that community of interest with England dictates that we retain the so-called English measures. As a matter of fact, England long ago abandoned the troy pound, and we are using a gallon and a bushel which England discarded decades ago, so that in respect to all dry measures, all liquid measures, and the ton weight, American practice already differs from English practice. It is as difficult for an American exporter to adapt himself to these measures in trade with England and her colonies as it would be for an American exporter to adapt himself to the needs of metric countries.

The following analysis may help the reader in coming to a dicision, if he has not already made one, as to whether to join in this movement on behalf of a change in our weights and measures or to sit back in smug satisfaction with America's system of weights and measures, the unsolved cross word puzzle of the world.

1. A uniform world-wide system of weights and measures used throughout the world, the Metric, the English, and the American. (Few realize that the English and American systems differ.)

2. Such a system should be adapted equally to the everyday uses of the people, to their trade and industries, and to science.

3. There are three major systems of weights and measures used throughout the world, the Metric, the English, and the American.

4. It is urged by some that the United States should abandon its present system and adopt the metric system for general use.

The problems to be considered are:

A. Which system is intrinsically superior.

B. Which system is best adapted to serve the uses of the people of the United States, and to promote their permanent interests.

C. What difficulties, if any, would a change of system involve, and how could they best be overcome?

D. Is it expedient now to seek legislation designed to affect the early or ultimate accomplishment of a change of system.

The questions at issue are first, is any change desirable?—second, if so what change?—and third, how can it best be accomplished?

Summarizing the arguments in favor of the complete adoption of the metric system, we find:

a. The metric system of weights and measures is now firmly established as an international system, either through its legal adoption, or its exclusive or permissive use for standards, by all the principal nations of the world. Its more general use in the United States is therefore advocated to promote greater international uniformity, and in the hope, if that be accomplished, that Great Britain (the only other country not completely metric) would follow the lead of this country.

b. The system has been tested and found satisfactory in the United States and elsewhere, in its use in complicated scientific calculations; and, in the metric countries, adaptable to the everyday trade, and to industrial and educational requirements of the people.

c. While the basis for the units of the metric system is, of course, arbitrary, it has now been definitely established, and the various decimal graduations give a wide choice for convenient designated measurements of length, weight and capacity, adaptable to common and scientific use. Familiarity with such terms as the pound and inch is a matter of habit, and it is certain that custom would also make the use of decimal subdivisions of the metric systems such as the millimeter, equally familiar and convenient.

d. The basic simplicity of the system, with its few units, as the meter, liter, gram, with decimal subdivisions, makes both teaching and learning easy; and, in trade, making computations and billing simple.

e. An arbitrary imposition of any system of weights and measures without a reasonable period of transition or the principle of exemption, where desirable for manufacture or for export to non-metric ports, might be a hardship. A gradual change has been effected in most countries, and it is believed that such change was accomplished without hardship and without heavy expense as claimed by those opposed to its adoption. It is also believed that greater uniformity to the habits of metric countries would tend to increase our export trade.

f. The relative international popularity of the major systems in use is shown by the vast number of nations which have adopted the metric system while none have formally adopted the English or American systems.

g. As further, domestic simplicity and international uniformity are believed to be desirable for local convenience and in our foreign trade, and as the further adoption by other countries of the English or American systems seems unlikely, it would therefore seem to be an appropriate time to make the change to the metric system. The education of hundreds of thousands of the present generation in the metric system through their overseas experience, and many more in local factory practice growing out of the late war, has laid a broad educational foundation and tended to develop interest in the subject.

When one considers the proposal to replace our complicated weights and measures with the metric system, there are three distinct impressions received which develop interest, convince the mind and, finally, enlist the heart!

First, it appears to be scientifically true—a proposal theoretically correct and desirable; then it is seen to be practical and economical—a means of saving much time and money; finally one realizes the moral wrong to children, to workers, to every one at home and to our neighbors—due to the inflicting of an archaic conglomeration of weights and measures upon these people. And with this final realization the demand for reform becomes a crusade!

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A Chemical Dictionary, Containing the Words Generally Used in Chemistry, and Many of the Terms Used in the Related Sciences of Physics, Astrophysics, Mineralogy, Pharmacy, and Biology with Their Pronunciations. Based on Recent Chemical Literature.

Ingo W. D. Hackh. P. Blakiston's Son & Company, Philadelphia, 1929. Cloth, 7 x 10 inches, 790 pages. Price $10.00.

In the literature of chemistry in the English tongue, the word "dictionary" is something of a misnomer. Through the excellence and the widespread use of the works which have preëmpted the field, the term has come to connote a work of cyclopedic character.

The recent book by Hackh is not a cyclopedia, but it is a dictionary in every true sense of the word—it has the form of a dictionary and it has the content and quality of a Dictionary with a capital D!

Considering the scope, and the detail, it is not a large book. It has been made with a utilitarian purpose which contrasts favorably with the frequent attempts to produce an imposing book through the expedients of padding and expansion. Compactness, which is a desideratum in any dictionary, has been achieved through concise definition, and intelligent attention to arrangement of material.

This arrangement is similar to that of some of our best medical dictionaries. For example, under *sodium*, this dictionary gives the essential information regarding character and uses; then, without repetition of the parent substance, it lists virtually in a single paragraph the compounds from *s. abietinate* to *s. zincate*. Separate paragraphing of the individual terms (the usual dictionary arrangement) would have required several times the present space with no resulting advantage, since the use of bold-face type makes the alphabetization readily apparent. It should be said that the publisher has had no small part in the excellence of the presentation.

In all walks of life there is a regrettable lack of knowledge regarding the proper use of dictionaries and the service afforded by the good ones. Young people and adults argue about the spelling, pronunciation, or derivation of a word, and attempt to settle the matter by writing to a newspaper! The use of the few important dictionaries of the English language should be taught in school (or, failing that, in college). Hackh's dictionary should form part of the teaching equipment of every instructor of chemistry. The beginner in chemical work who requires orientation in the various branches of the profession will find under "Chemistry" more subdivisions of the subject than he knew existed.

Derivation of words is not included, but pronunciation is indicated, a simple key, avoiding diacritical marks, appearing on every page.

There are some omissions, of course. These will be detected with some sense of elation, because the approach to exhaustiveness constitutes a challenge to find something which has been overlooked. The remarkable thing, however, is that a first edition of any dictionary covering so broad and intricate a field should be so nearly complete. It contains many terms which have found their way into general dictionaries only very recently, if at all, and includes some (such as "balopticon" and "klydonograph") from the borderland of chemistry.

The dictionary includes the names of many chemists (living and dead) with very brief notes regarding their achievements, and with occasional portraits. This feature probably presented one of the most difficult problems of compilation, but the result, as regards contemporaries, is a little bewildering. The reviewer ventures the prediction that many a user of the book while searching for something else will run across the name of Bill Jones, able-bodied chemist, and will thereupon promptly look for his own name, probably to be disappointed.

Brief use and somewhat superficial examination would indicate that it deals more fully with pharmacy and botany than with some of the other allied branches of science. It does not, of course, attempt to cover all of metallurgy, so there will still be use for H. P. Tiemann's "Iron and Steel."* Within the field of chemistry itself it does not attempt the inclusion of commercial information regarding containers, fire hazard, and shipping regulations such as is given briefly in the "Condensed Chemical Dictionary"† (now being revised).

In announcements of this dictionary, attention has been called to the statement in "Crane and Patterson"‡ that "There has been in modern times no adequate general dictionary or *wordbook* of chemistry . . ." The claim is that this gap in the literature has now been filled by Hackh's "Chemical Dictionary." To a very material extent, this is true. It is a very useful book, at present without a rival.—E. H. McClelland.

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*McGraw-Hill Book Company, New York. 1919.

†Chemical Catalog Company, Inc., New York. 1919.

‡"Guide to the Literature of Chemistry" by E. J. Crane and Austin M. Patterson. John Wiley and Sons, New York. 1927.

X-RAY TECHNOLOGY. *H. M. Terrill & C. T. Ulrey.* D. van Nostrand Co. Inc., 1930. Cloth, 6x9¼ inches, 256 pages, 143 figs. Price $4.50 Postpaid.

X-rays are now used for so many purposes that "X-ray Technology" may be expected to be of interest to scientists n widely different fields. Particular attention has been given to the quantitative measurements involved in X-ray therapy and in industrial applications but most of the material presented is of interest to all who are engaged in the production, measurements, or utilization of X-rays.

Much of the contents of the book may be classified as X-ray engineering. Emphasis has been placed upon the practical rather than the theoretical aspects of X-ray measurements and considerable space has been devoted to the description of modern X-ray apparatus and the methods of using it. No mention is made of the vario in types of gas filled tubes that are still of utility for certain purposes, but the manufacture and operation of Collidge X-ray tubes are treated in some detail. A chapter on the different types of high voltage generators used for X-ray work is followed by a description of the instruments and methods used to measure the current and voltage supplied to the X-ray tube. Succeeding chapters deal with ionization, total energy, wave-length, and biological measurements of X-rays. The concluding chapters discuss briefly the use of X-rays in radiography, and in the applications of X-ray spectroscopy and crystal structure analysis.

The book contains a number of practical suggestions wth regard to the proper use of X-ray apparatus and should be a useful addition to any X-ray laboratory.—J. B. Friauf.

COMMERCIAL A.C. MEASUREMENTS. *G. W. Stubbings.* Chapman & Hall, Ltd. London, 1930. Cloth 6x9 inches. 341 pages. Price $5.00.

The book deals with the theory of a. c. measurements and while somewhat technical is so well written that it will be easily understood by the average engineer.

At the end of each chapter a reference is made to articles that have appeared on the subject discussed. Practically all references, however, refer to British publications. This of course, is to be expected.* The papers referred to are all well selected.

The arrangement of the book is good and the subject well covered, discussing in addition to the instruments themselves, and their use, also accessory apparatus, such as instrument transformers, etc.

The reviewer is certain that a great deal can be learned from this book, and recommends it highly to engineers who are called upon to make a. c. measurements. It can also be recommended to students who are studying a. c. measurements as the subject is presented in a very clear cut and precise manner. The reviewer does not hesitate recommending it to the readers of INSTRUMENTS as it covers the subject better than any other book, which has come to his attention.—E. S. LINCOLN.

HANDBUCH DER WISSENSCHAFTLICHEN UND ANGEWANDTEN PHOTOGRAPHIE. *Edited by Alfred Hay.* Volume IV. ERZEUGUNG UND PRUEFUNG LICHTEMPFINDLICHER SCHICHTEN. LICHTQUELLEN. *Edited by Dr. S. M. Andresen, F. Formstecher, W. Heyne, R. Jahr, H. Lux, and A. Trumm.* Verlag Julius Springer, Vienna, 1930. Cloth, 7x10 inches, 344 pages, 126 figs. Price $10.00.

The handbook is an instrument for those who are interested both in the applied and the scientific aspects of photography. Lux, in the first section, reviews the more essential laws of temperature radiation and also gives important characteristics of the various sources of artificial light. A knowledge of these fundamental laws of radiation is important in the choice of the proper type of illumination in photography. An explicit treatise on the subject of magnesium as a source of artificial light is presented by Andresen. He treats the chemistry of magnesium as well as the apparatus required in its application to photography as a source of artificial illumination. Sensitometry is discussed in the third section by Fromstecher. He divides the general subject into three subheadings of apparatus, practice, and theory of sensitometry. Numerous illustrations and curves aid considerably in the concise presentation of this subject. Further, with the help of references the section is brought up to date. The manufacture of the photographic dry plate is described in a condensed fashion. Jahr touches on the historical development, on the preparation of the gelatin emulsion, and on the various other steps in the production of the photographic dry plate. One gains a clear conception of the manufacture of the photographic dry plate from Jahr's chapter.. A short chapter by Heyne is devoted to the manufacture of the photographic film. Sufficient space is hardly allotted to permit presentation and discussion of the subject in accordance with its importance. Certain types of apparatus essential to the production of the film base and emulsion have been described. A type formula for negative and one for positive emulsions are given. The final chapter is devoted to the preparation of photographic paper. Trumm describes and illustrates some of the apparatus essential in the manufacture of the various kinds of photographic papers.

The subject, production and examination of light sensitive layers, is presented in a manner such as to warrant the study of the handbook by all those interested in photography.—W. Vanselow.

(Continued on Page 368)

Measurement of Air Flow

E. OWER, B.SC. (LOND.), HONS.I., A.C.G.I.
Bramwell Medallist; Member of the Institution of Heating and Ventilating Engineers; Assistant in the Aerodynamics Department, National Physical Laboratory

CHAPTER V—*(Continued)*

Practical Notes on the Use of Pitot and Static Tubes.—In determining the mean rate of flow or the mean total head at a section, we have seen that the Pitot and static tube must be inserted into the pipe through a hole cut in the side, and traversed across the section, readings being taken at a number of pre-determined points. It is convenient to provide a number of wire rings fitting the stem of the instrument fairly tightly, whose positions can be adjusted prior to the insertion of the tube into the pipe, so that when each ring in turn is up against the outside of the pipe, the axis of the head is at one of the desired positions inside. A linear scale marked on the stem further facilitates the correct location of the points of measurement.

The head of the instrument should, of course, point upstream, with its axis parallel to the direction of motion of the air, which is usually assumed to be parallel to the walls of the pipe. A useful method of ensuring that the head is in the desired attitude is to have, permanently fixed to the extreme end of the stem outside the pipe, a straight-edge, five or six inches in length, parallel to the head, which can be sighted along the outside wall of the pipe. The hole cut in the pipe wall should not be larger than is necessary for the introduction of the tubes, and should preferably be, as far as possible, stopped up when the instrument is in place.

Combined Pitot-static tubes of the N.P.L. pattern or of the alternative type shown in Fig. 9 may be used in pipes up to about 15 inches diameter, but in practice it frequently happens either that the length of these tubes is too short to permit them to be traversed completely across a section of a pipe or that the instruments are unsuitable for some other reason. In such cases, when modified forms of Pitot tubes have to be made up to suit particular conditions, it obviously simplifies construction to have the total head and static tubes separate, and to clamp them in juxtaposition. Satisfactory apparatus can be made from material to be found in the ordinary works machine shop: steel or brass tubing of about $\frac{5}{16}$ or $\frac{3}{8}$-inch external diameter is quite suitable for most purposes. Some care is necessary in shaping the heads of both tubes if it is intended to use them clamped together. Although any open-ended tube facing the wind will indicate total head correctly, if the tubing is at all thick-walled the flow of air around the outside will be somewhat disturbed, and may therefore lead to error in the measurement of the static pressure by means of another tube placed near the first. For this reason it is advisable to file the outside of the total head tube near the end to form a taper, so as to present only a thin annular edge to the wind. For the static tube it will probably be found simplest to adopt the type having a hemispherical nose. This tube can easily be constructed by bending a straight piece of tubing to form the head and the stem, and closing the open end of the head by means of a hemispherical plug having a short shank that forms a push fit or screws into the tube, the joint being made airtight by finishing it off with solder. Care should be taken to leave no gap between the plug and the end of the tube: the outline of the head should be smooth and continuous. The static holes should be six tube diameters behind the junction of the plug and the head, and the stem eight diameters behind the holes, if convenient. In this case the tube will indicate the static pressure correctly, but if, for some reason, it is more convenient to have the stem at some other distance behind the static holes, the correction to be applied to the observed pressure in order to obtain the true static pressure can easily be obtained by reference to Fig. 8. The actual size of the static holes is not of great importance, provided they are not too large; a diameter of about 0·05 inch in $\frac{3}{8}$-inch diameter tubing is quite suitable. It is important that in drilling the holes the outside of the tube should be left entirely free from burrs.

When separate total head and static tubes are used clamped together, the air flow round each will be affected by the presence of the other, so that if the tubes are too near each other the accuracy of the static head reading will be impaired by the interference effect of the total head tube, although the reading of the latter will not be correspondingly affected. Experiments made by the author have shown that the tubes may safely be clamped with their axes not less than 5 tube diameters apart. Similarly, all brackets and clamps should preferably be confined, if possible, to the stems of the tubes outside the pipe, in order that they should not vitiate the static pressure observations by giving rise to disturbances similar to the effect of the stem.

It may be mentioned here that when separate tubes are used for the measurement of total head and static pressure, these observations need not necessarily be made simultaneously provided the conditions of flow are reasonably steady and constant. It is often more convenient to read first the static pressure and then the total head at the point (or *vice versa*), the appropriate tubes being successively introduced into the pipe. This necessitates the cutting of smaller holes in the piping than when the tubes are inserted clamped together. The velocity head is then, of course, obtained by subtracting the observed reading of the static tube from that of the total head tube, due attention being paid to the signs of the observed pressures (i.e. whether they are above or below the atmospheric pressure).

Readings of Fluctuating Pressures.—Serious difficulty is frequently experienced in Pitot-static observations on account of the unsteadiness of the air stream. In such cases the liquid in the manometer oscillates, at times over a large range, and it is not easy to estimate the mean value of the pressure to the necessary degree of accuracy. A method of overcoming this difficulty has been suggested by Mr. L. F. G. Simmons of the National Physical Laboratory. It depends in principle on the fact that a fluctuating pressure acting on one end of a long tube is not transmitted instantaneously to the other end. Moreover, the amplitude of the transmitted fluctuations is not the same as that of the applied fluctuations. A tube of given dimensions exerts, in effect, a definite amount of damping on the motion of a pressure wave along its length. Now the amount of damping contributed by the total head tube will obviously be less than that of the static tube on account of the larger resistance of the small static orifices. Hence, even if the same fluctuating pressure acts both at the mouth of the total head tube and at the static holes, the fluctuations will not be damped out to the same extent by the time the pressures are transmitted to the manometer, unless extra damping is introduced in the total head connecting tube. It appears, therefore, that the total head connection must be made longer than the static connection.

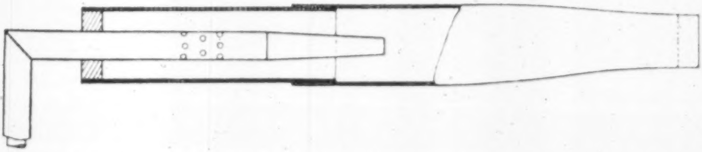

FIG. 24.—Method of equalising the damping on both sides of a Pitot-static tube.

The necessary lengths of tubing can readily be determined by the method illustrated in Fig. 24. The head of the Pitot-static tube is introduced through a cork into a length of brass tubing about $\frac{3}{4}$ inch in diameter, the other end of which is connected, as shown, to a convenient length of large-bore rubber tubing closed by a second cork. By squeezing this rubber tubing in the hand, fluctuating pressures can be applied simultaneously to the mouth of the total head tube and the orifices in the static tube. If the other ends of these tubes are connected to the manometer in the usual manner, the lengths of the connecting tubes can be adjusted until the oscillations of the manometric liquid become quite small even for large applied pressure fluctuations. When the required lengths of tubing have been thus ascertained by trial and error, it will be found that even under unsteady conditions of measurement sufficiently steady readings will generally be obtained on the manometer.

On the assumption that the same fluctuations of pressure act on both the total head and static orifices, and that this pressure oscillates symmetrically about a mean value, the resultant reading on the manometer will be the velocity head corresponding to the true mean rate of flow at the position occupied by the Pitot-static tube. Actually, these conditions will not be completely realised. The total head fluctuations will be a combination of velocity and static pressure variations, whereas the static orifices will be affected only by variations of static pressure. Hence a system balanced in the above manner under pressure variations only, will not give entirely steady readings when used to measure flow in a pipe where the velocity and static pressure are both fluctuating. It will nevertheless usually be found that greatly improved steadiness can be secured by adopting the procedure described above.

* * *

At the Medal Day exercises held May 21, 1930, in the Hall of the Franklin Institute at Philadelphia, Pa., Ervin G. Bailey, President of the Bailey Meter Company, Cleveland, Ohio, and a widely known engineer was awarded the Edward Longstreth medal by the Institute.

Mr. Bailey received the medal upon the recommendation of the Institute's Committee on Science and Arts in recognition of his many inventions and developments of regulating and controlling devices, and of measuring and recording instruments.

Measurements

Industrial & Scientific

An Instruction Book for Engineers

DR. WALTER BLOCK
Eichungsdirektor der Provinz Ostpreussen

CHAPTER IV. MEASUREMENT OF TIME

ASTRONOMY has taken over fixing the unit of time. Astronomically, a distinction is made between two time units: sidereal time and solar time. The sidereal day is the time which elapses between two consecutive passages of a fixed star through the meridian of the location of observation, that is the time between the two instants at which the star was exactly south on two consecutive days. This time interval is the sidereal day which, as usual, is subdivided into 24 hours of 60 minutes and 60 seconds. This is the astronomical time unit while that of civil life is the so-called solar day which is determined in exactly the same manner with the difference that the sun is used instead of a fixed star. Considering the rotation of the earth around the sun it is at once obvious that both days are not the same. A simple reasoning shows that during one year, that is in approximately 365 days, the solar time must have preceeded sidereal time by a full day due to the complete rotation around the sun. More exact observations show that a solar day is longer than a sidereal day by 3 min. 55.9 sec. Due to the fact that the rotation velocity of the earth around the sun is not quite uniform in the course of the year the length of the solar day is consequently not quite uniform during the year. The average length of a solar day in the course of a year, according to what was said before is the mean solar day, the well known time unit of civil life.

To make use of the astronomically determined time offers no difficulties at present. It may, for instance, be pointed out that the large German* radio station at Nauen gives a radio time signal at 13 o'clock (i. e. 1 P. M.) which is supplied by the Deutsche Seewarte in Hamburg or the observatory in Bergedorf near Hamburg. The reliability of this signal can be estimated to more than 0.1 second, and it is usual that all radio stations pass this signal on, of course with the same accuracy. This signal can be received with little difficulty with simple apparatus almost everywhere and clocks and watches compared with it. Further, many foreign stations send out similar time signals.

Clocks are the well known time measuring devices which are made in two types with pendulum and with balance-wheel, the latter is known as the watch. The time measuring device of the former type is the pendulum. A pendulum which can oscillate permanently without friction would be the best time measuring device. Unfortunately, it is influenced noticeably by several conditions, first by the friction of the pendulum in the ambient air, then by the unavoidable temperature expansion of the pendulum rod which changes the length of the pendulum and therefore the period of oscillation, and finally by the unavoidable energy consumption of the oscillation. For very high-class clocks nickel-steel with very low expansion is used for the pendulum rod and the influence of temperature can be compensated with astronomical accuracy on the rod by compensating devices (Fig. 15). The wooden rod is appropriate and entirely satisfactory for the pendulum. The length is usually selected so that it beats seconds. A further hindrance to the free movement of the pendulum is the transmission of the oscillations of the pendulum to the clock-work. The clock-work itself is a purely mechanical arrangement the construction of which offers no great difficulties if it is made with a little care, but it is fairly difficult to transmit the oscillations to the clock-work in such a manner that the pendulum is impeded as little as possible, and that, at the same time a uniform suitable power transmission to the pendulum from the driving weight, necessary for the maintenance of the oscillations, is guaranteed. A spring drive for the pendulum is inferior to a drive using weights.

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*In the United States by the Radio Station at Arlington.

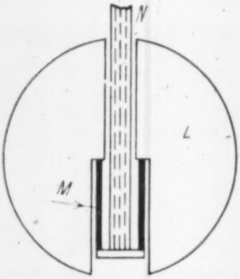

Fig. 15. Sketch of a compensated pendulum. L pendulum weight rests on a brass tube M, attached at the bottom of the nickel-steel bar N. An expansion of N downward is compensated by an expansion of M upward so that the location of the center of gravity of L remains unchanged, N has small, M large temperature expansion.

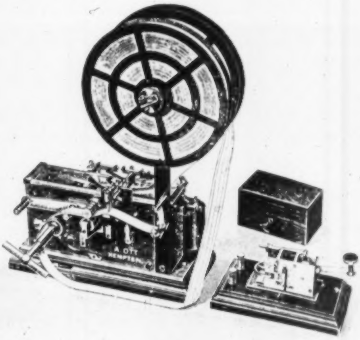

Fig. 16. Chronograph with Morse key.

The pendulum clock has, above all others, the great practical advantage of permitting the electrical transmission of the movement of the clock to other places with ease. It is quite easy to provide the pendulum with electrical contacts which at each oscillation send a current impulse into a line and so operate other devices. Such devices are for instance secondary clocks without clock-work, the hands of which follow perfectly from second to second the position of the hands of the primary clock, or also so-called chronographs, that is devices which indicate or record on moving paper ribbons from second to second.

Such chronographs, are used in order to be able to conveniently compare any occurrences in their chronological order with the time indications of a clock because they are to be considered, so to speak, as a normal accessory to a pendulum clock in a laboratory. It has been said above that only a pendulum clock permits making electrical contact in simple manner by a suitable arrangement of its pendulum. This is done either by passing the lower end of the pendulum through a mercury container on each passage through the vertical position and thereby closing an electric circuit, or by arranging a suitable contact on the pendulum rod itself. This never causes difficulties provided care is taken that the surface of the mercury remains sufficiently pure which can be fairly easily accomplished if it is protected by a film of oil or petroleum. The standard chronograph (Fig. 16) originated from the ordinary Morse-telegraph key. A small paper ribbon, on which two pens can write, runs through a clockwork with approximately uniform speed. The two pens make either straight lines or are suspended close to the paper ribbon. At their other end is placed an iron piece over an electromagnet. If the clock closes the circuit the iron is attracted, the pen attached to this iron piece indicates a jog in the straight line or marks a dot on the paper. The same is done by the other pen as soon as its electric circuit is closed. This must be done by hand at the proper moment or by the apparatus observed. Corresponding arrangements are made in many recording devices where a pen marks seconds on the moving paper.

The second type of clocks which are of importance are the clocks with balance-wheels or chronometers. They are particularly suitable for portable clocks because it is obvious that a pendulum clock can only be transported with considerable difficulty and grave disturbance to its movement. A particular type of chronometer is the so-called marine chronometer which is also a larger size balance-wheel clock built with special care for navigation purposes. They are of extraordinary accuracy so that they are hardly inferior to average pendulum clocks.

The power for driving these clocks is supplied by a spiral spring the torque of which, however, depends to a considerable extent on the degree of winding, and which is, therefore, only used to a small degree so as to attain uniform operation.

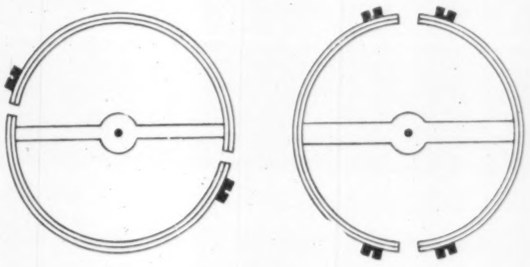

Fig. 17. Bimetallic balance wheels for chronometers.

The counter-part of the pendulum is the balance-wheel in this clock. In cheap watches the balance-wheel is a simple brass ring oscillating around its axis. To produce this oscillation the spiral spring is attached to it which can be seen in each watch; one end of the spring is fastened to the bearing of the axis of the balance-wheel the other to the axis of the wheel itself. The spring is of steel, sometimes of gold or palladium. It is self evident that the action of balance-wheel with spring, depends in a large measure on the temperature as temperature not only changes the dimensions but also the elastic constants. Recently, the metal Elinvar of Guillaume is often employed in high-grade watches for the spiral, a special nickel-steel alloy which has not only a very small temperature coefficient but it also practically independent of temperature. The shape of the balance spring in most watches, is flat, in marine chronometers often cylindrical. In oscillating it changes its shape displacing the centre of gravity which is not conducive to uniform movement. This condition can be eliminated by an appropriate shaping of the end curve of the spring, an invention of very great importance for the watch making art.

In its simplest form the balance-wheel is a ring. This form is only suitable for watches of rather low accuracy as temperature changes have a very great influence on it. It may be mentioned that a solid brass balance wheel with steel spring which is correct at one temperature would have an error of 10 seconds daily with a 1° C temperature increase. In order to equalize the temperature error usually a balance-wheel with a so-called bi-metallic rim is used (Fig. 17). This is cut in two places on a diameter and the two so formed semi-circular pieces are composed of two different metals so that their free ends curve more or less with temperature changes and move closer or farther away from the axis. In this way, the moment of inertia of the balance-wheel is changed and it is possible to eliminate the temperature influence on its movement. For finer adjustment, tiny screws are provided on the circumference. In many watches of average quality the bimetallic balance-wheel is only pretended but not actually carried out. The most important part for the movement of the watch is the so-called escapement, the same as in the pendulum clock. Here, also a great number of types are in use which will not be discussed here.

It is usual to adjust the ordinary watch so that the balance-wheel makes five oscillations in one second. In marine chronometers two oscillations per second are usual. A watch can, therefore, quite well be used for estimating tenth of a second, a fact not quite generally known.

The errors in the movement of the clock which is to be used for measuring purposes must of course be known. It is customary to designate these errors in such manner that they must be added with their signs to the reading of the clock in order to obtain correct time. For example: if a clock has an error of +5 seconds that means that the clock is slow 5 seconds, an error of −5 seconds that it is fast 5 seconds, that 5 seconds have to be subtracted from its reading to obtain correct time. A good time-piece should have constant error. This condition is fullfilled by pendulum clocks according to their quality with quite extraordinary accuracy. Balance wheel clocks are much inferior in this respect as they are more complicated in construction and subject to more external influences. In particular the balance spring will gradually change its elastic qualities due to the fatigue, rust also may influence it, the friction conditions of its gears in their bearings; the influence of the oil also causes considerable variations. However, watches which can be adjusted with proper care so that they show only changes of a few seconds during one week are available at present.

A special type of watch is the so-called stop-watch, the use of which is well known. It is usually a medium quality watch so modified that the principal hand of the watch is the seconds hand which rotates once in a minute. The movement can be stopped by a pressure device and also started by it. In addition a device for returning the hand to the zero position is provided. Due to the jerky progress of the hand by the oscillations of the balance, naturally only about 1/5 of a second can be measured which can also be read on the dial. Recently, similar watches have been put on the market which are said to do better than this. Their application should be rather useless since, from the purely physiological point of view, time readings can hardly be made with greater accuracy.

CHAPTER V. MEASUREMENT OF ANGLES

1. General

It may be said that angles are one of the units of measurement which do not require a standard for their embodiment as the unit of angle is represented by the division of a full circle which is divided into a certain number of parts. At present after an agreement of centuries long standing the division of 360° has been chosen, i. e. the right angle contains 90°, and each degree 60' of 60". More recently, instead of this, a division of the full circle into 400° has been chosen due to the simpler calculation, so that the right angle has 100°. A further subdivision into individual parts does not exist; smaller angles than 1° are simply expressed in decimal fractions of a degree. A number of tables for the angle-functions have already been computed for the calculation with this new division. Also measuring instruments with these divisions can be bought but are of special interest only to astronomers and surveyors. In any case, the subdivision of the full circle into a certain number of degrees is a purely mechanical matter, and the division of an angle can be carried out correctly without official supervision provided suitable devices exist which is impossible for lengths and masses. It may be said that generally very exact divisions of angles offer less difficulty than divisions of lengths from a precision machining viewpoint.

Omitting the cases of diagrams, the chemist will only find it necessary to measure angles, when the angles of crystals must be determined because these are of importance crystallographically and therefore also chemically for the determination of minerals.

The measuring instrument used in this case is the so-called reflection-goniometer which is built in more or less precise models by several companies (Fig. 18). It consists essentially of a crystal holder to which the crystal to be determined is attached in such manner that it can be adjusted in all directions. This adjustment must be made so that the line of intersection of the two crystal faces, the intersecting angle of which is to be measured, coincides as nearly as possible with the axis of rotation of the crystal holder or runs parallel with it and very close to it. Around this axis of rotation, a divided circle also rotatable is attached so that the circle rotates simultaneously with the crystal holder or the crystal holder independently of the circle. The rotation of the divided circle is read at fixed marks at two diametrically opposite places. The procedure for measuring is as follows: A stationary telescope is directed on one of the crystal faces which necessarily must be plane and reflecting; in this face, a distant mark is reflected. For this, either any mark in the open or any other suitable object, for example, a mark on a window frame or something similar, is used. The only requirements is that it must be far enough away. The light falls from this mark on the crystal face and is reflected when in suitable position by the face into the telescope and made visible in the latter. The crystal face then has a distinct location with reference to the direction of the axis of the telescope which is perfectly defined by the cross-hairs in the ocular lense and the axis of the telescope. The crystal is rigidly connected with the divided circle and this position is now read. Then, both are turned together until the light is reflected by the second crystal face in exactly the same manner, until the same mark appears at the same place in the field of view in the telescope. This position is also read. The difference between the two readings gives the angle directly taking into account any passage of the zero point. As can be seen from Fig. 18 a very simple relation exists between this angle and the angle of the two faces. Both must necessarily supplement each other and must equal 180°. The crystal angle can, therefore, be calculated directly from the angle determined.

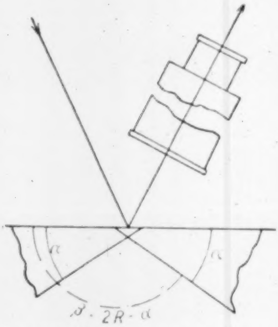

Fig. 18. Diagram of the reflexion-goniometer.

In practise, one usually proceeds in a different way. The measurement is made in the manner described by adjusting and reading the starting position, then the final position is set, this though is not read or only approximately read. Then the crystal without the circle is turned back and again adjusted without reading finally the crystal together with the circle is again turned to the adjustment of the second face and now an exact reading is made. It is quite evident that, in this manner, the double angle has been measured, and that with the same accuracy as the single angle. The difference of the readings must, therefore, be divided by two, and in this way the accuracy of measurement is almost doubled, disregarding errors of adjustment. The same method can be repeated several times and the accuracy thereby increased still further. This method which is also of importance in other angular measurements, is called the repetition method.

It was mentioned above that the goniometer has two reading marks for reading the division circle. This fact which is of importance for many other measuring instruments may be treated a little more thoroughly. If a division of a circle is made which is accurate this entire division holds good only for one well defined center of the circle. If two oppositely located divisions are connected all these connecting lines should go exactly through the same point; this is the center of the circle and of the division. Such circular divisions for angle-measuring instruments are always mounted rotatable on axes, or on other axes which carry the actual measuring instruments, which should coincide with the axis of the division circle. This condition can, of course, not be strictly fulfilled considered from a precision-machining point of view, and if, therefore, the finished division circle which is correct in itself, is mounted in a goniometer or a spectroscope its new axis of rotation will not, in all cases, coincide with the axis of the division circle, that is to say, if a line is drawn from one division through the new axis to the opposite side this line will not exactly pass through the corresponding division, and it is evident that the division is apparently incorrect because this division corresponds in fact to an exact rotation of 180° while the line which indicates this angle is displaced more or less to one side or the other. These errors are called errors of eccentricity, and they can be avoided comparatively easily by always reading all circular divisions at two points approximately 180° apart. In practice this is done by taking one of the two marks as the principal one and making a full reading while for the other, considered as secondary mark, only the minutes are read which of course will differ only little from the first reading of minutes if the instrument is made with fair precision; of these two readings of minutes alone the average is then taken.

2. READING WITH MIRROR AND SCALE

At this point, attention may be called to a special measuring method which can also be used for the measurement of angles, especially of small angles, but which is also of particular importance for other measuring purposes. This is the reading and measuring of rotation angles of instruments of the most varied types, in particular of galvanometers, by means of a mirror and scale, generally called by Gauss and Poggendorff mirror-reading (Fig. 19). In principle the method consists in that the body, for example the magnet needle of a galvanometer, is provided with a mirror which follows all its movements. At some distance a scale is arranged so that the plane of the scale and that of the mirror are parallel when the latter is at rest, and closely above or below the scale a telescope is directed on the mirror in such a manner that an image of the scale is seen in the mirror. In the telescope itself a cross-hair is arranged so that a certain line of the scale is seen in the mirror and can be read when the mirror is at rest. If the mirror is turned a small amount the lines of the scale are seen passing in the telescope and a second line can be read when the mirror has come to rest again so that the rotation of the mirror can be brought into a simple relation with the reading of the scale. As can be seen from Fig. 19 a simple mathematical relation exists between the angle of rotation of the mirror and the difference of readings on the scale: tan. $2\alpha = b/l$.

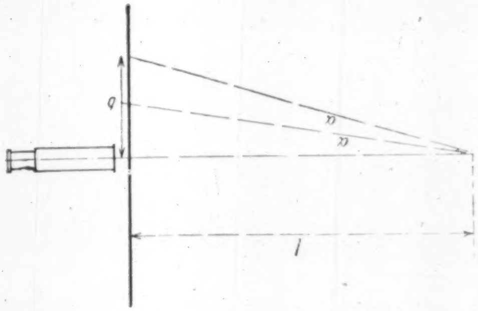

Fig. 19. Diagram illustrating reading with mirror and scale.

This method is so important, especially for electrical measurements that it deserves a somewhat more detailed treatment. At first something more may be said about its use. Generally, the distance between mirror and scale is chosen to be from 1 to 5 mm. To place the telescope farther away than the scale is of no use as the distance of the former has no influence only the distance of the mirror scale is of importance. The size and capacity of the telescope is of importance in so far as it must permit clearly seeing the divisions of the scale. The scale is placed so that its center vertical line passes through the rotating mirror and about the center of the scale can be seen in the telescope when the mirror is at rest or zero position. One must note that the scale can not be seen in the telescope if one adjusts the mirror itself, but the telescope must be adjusted to a vision distance corresponding to the total distance telescope-mirror-scale.

Reference to Fig. 19 shows that the deflection read on the scale corresponds to the double angle of rotation. In the great majority of measurements as they are used for instance for electrical measurements the actual angle of deflection is entirely immaterial, and only in special cases will it be necessary to change from the deflection to the angle itself. In general, it will suffice to assume that the deflection is proportional to the angle of rotation, and that corrections therefore do not become necessary.

With respect to the practical use of this method a few peculiarities may be pointed out. When taking long series of measurements it becomes tiresome to look through a telescope. There are, therefore, some types on the market which permit an objective reading; if the galvanometer is provided with a suitably curved mirror instead of a plane mirror and a bright line is used as the mark, (the straight filament of a special incandescent lamp) an image of the filament can be thrown directly on the scale by means of the mirror and, in this way, the deflections be directly observed without the eye being at a fixed place. Precisely the same object is attained if a suitable lens is inserted in the path of the rays, most suitably in close proximity to the mirror; this makes the use of a curved mirror unnecessary. They have the further advantage that with their application the comparatively large space is not required which the original arrangement requires. Usually the arrangement is so that the path of the light is bent by prism and the galvanometer placed on a socket high up on the wall, while the illuminating lamp and scale are mounted below the galvanometer on the wall. This also gives the advantage that the place for the scale can be chosen so that the scale is somewhat in the dark which of course facilitates reading, and it can be mounted directly above the work bench where other measuring instruments are placed which permits observing the scale and instruments simultaneously. The accuracy of reading with objective reading may not be quite as good as when reading through a telescope, the latter is more accurate only when the power of the telescope is fairly high. In practice both methods can generally be considered equivalent. The objective method is, without doubt, much more convenient for the observer, especially for longer series of observations, and is very flexible if plane mirrors and lenses are used rather than concave mirrors as the distance can be changed by simply changing lenses. The sensitivity of the method can still be increased by placing a stationary mirror opposite the rotating mirror and reflecting the light rays several times between both. For very precise measurements of angles, however, this method can only be applied for increased sensitivity zero deflection in observations, that is only for determining with increased accuracy whether the mirror is really at rest or not.

3. Levels

One general instrument for measuring angles must still be discussed more in detail due to its frequent application in connection with other measuring instruments. This is the level, an angle-measuring instrument, or better, an instrument to adjust lines or surfaces in definite relations to the horizontal plane. In principle, levels are containers of suitable shape which are almost wholly filled with liquid except for an air bubble, and for which a certain position of the bubble indicates the normal position of the level. If the level is attached to any portable instrument then the adjustment of the latter so that the air bubble takes a certain position, gives assurance that the instrument always has the same position with reference to the horizontal.

Two kinds of levels are distinguished, box-levels and tube-levels. The former kind is a circular glass container with a glass cover which is ground spherically with comparatively long radius on the inner side. the container is filled with a suitable liquid. Generally alcohol, ether, or easily movable and well moistening liquids are used, sometimes they are slightly colored. For levels of lesser quality the glass box is glued on or placed in a metal housing, better grades are made entirely of glass which, after filling are sealed by fusion and put into a suitable metal casing. The sensitivity of levels varies, depending upon the curvature of the inside of the top. Box-levels are generally of low accuracy.

Tube-levels, which consist of a cylindrical glass tube ground spherically at one place on the inside are better. This grinding can be done much better and more accurately with fairly large radius and, therefore, higher sensitivity of the levels results. The glass tube is generally provided with divisions so that small changes of angle can also be read. Usually, the division is made so that its value corresponds to a round number, for instance one second, which corresponds to a radius of curvature of the inside grinding of about 630 mm at 3 mm intervals. In general, the following mathematical relation exists, if p is the length of a division of the level with the arc α and R is the radius of curvature: $p = R\alpha$, α (in seconds) $= 0.21 \times 10^6 \times p/R$, α (in minutes) $= 0.34 \times 10^4 \times p/R$.

Good tube-levels are, just as box-levels, wholly enclosed. The adjustment in the casing which is provided for all better instruments is of importance; it is accomplished as follows: the level is placed on a suitable plate which is fairly horizontal and can be adjusted by adjusting screws, so that the level is parallel to two adjusting screws; by turning these screws the level is brought to zero position, and then the level is turned 180° horizontally where very likely the bubble will no longer be in zero position This is accomplished by correcting half the deviation on the screws of the plate, the other half on the adjusting screws of the level. After again turning 180° the same is repeated if necessary, and so on until the same position of the bubble is obtained when turning the level; then both the surface of the line connecting the two screws and the base of the level are horizontal. The latter is the determining factor for the adjustment of the level. If, therefore, the level is placed on another surface and the bubble shows zero position, one knows that this surface is horizontal. Of course, this must be done in two positions differing by 90° horizontally in order to obtain a wholly horizontal position.

The length of the buble in the level which, by the way, is always read at both ends (Fig. 20) depends to a large extent on the outside temperature for which reason special types of levels are built, which contain a small special space at the end of the tube into which part of the bubble can be made to enter in order to adjust the latter to a certain length.

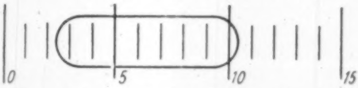

Fig. 20. Reading of level. $\frac{1}{2}(2.4 + 10.4) = 6.4$.

It is often necessary to have at least an approximate indication as to the sensitivity of the level. A suitable arrangement can easily be improvised as, generally a special level-tester will not be at hand. This can be done by placing a sufficiently strong iron bar approximately horizontally so that the bubble of the level is adjusted approximately on the one end of the tube; then one end of the bar is raised so that the level is adjusted at the other end. The mean values of the displacement of the right hand and left hand end of the bubble are read on the division of the level, and also the length of the bar is measured from one end to the point of support, and the amount the bar was raised. An example will illustrate this: the level is placed on an iron scale of 1 m length. Position of bubble at the left end 0.2-4.8, average 2.5. The right end of the rule is raised by placing a 0.5 mm sheet under it, new position of the bubble, right end, 18.3-23.1, average 20.7. Movement of the bubble therefore 20.7-2.5 = 18.2 divisions. The latter corresponds to an angle of 0.5/1000 expressed in arc, that is 0.0005. As is known angle 1 equals 57.296°, therefore 1° = 1/57.296 = 0.01746, 1' = 0.000291. The value of one division of the level is therefore:

$$\frac{0.0005}{0.000291} = 1.7 \text{ minutes}$$

INSTRUMENTS BOOK SHELF

The books reviewed in this section can be supplied by Instruments Book Shelf, Instruments Publishing Company, Pittsburgh, Pa.

DIE ELEKTRISCHE MESSTECHNIK. II. Die Messungen an elektrischen maschinen Transformatoren und Gleichrichtern. *Prof. Dr. G. Brion.* Walter de Gruyter & Co., Berlin, 1929. Cloth 4¼x6¼ inches, 120 pages, 96 figs. Price 75 cents.

To condense into the space of 120 pages of pocket-book size the vast field of electrical measuring methods is not an easy undertaking, and it can only be accomplished if the fundamentals of electro-mechanics and electro-physics are assumed to be familiar to the reader. The author, therefore, has omitted practically all explanations and given in this book a bare description of methods necessary for testing electrical machinery. First, general mechanical measurements as speed, acceleration, inertia and torque, are treated in a more complete manner; then come general electrical measurements applicable to electrical apparatus in general, as coils and windings, magnetic properties, voltages, temperatures, and the taking of characteristic curves. Then follow chapters of specific measurements on d. c. machines, a. c. synchronous generators, transformers, induction motors, etc. In conclusion, rectifiers and rotary converters are treated very briefly.

This little booklet is of value to men who know what they are about to do but require a short manual which can be consulted to give general information in case of necessity.—Max Hartenheim.

DIE OPTISCHE WERKSTATT. *W. Ewald.* Gebrueder Borntrager, Berlin, 1930. Cloth, 6¼x9½ inches. 277 pages, 169 figs. Price 20 marks.

This book is written primarily for the worker in an optical shop, but it will probably prove more valuable as a textbook for beginners in the field. The greater emphasis is upon the making of spectacle lenses, only brief mention being made of lens mountings and compound lenses. The book is descriptive rather than theoretical in its treatment of the subject.

The book is divided into three parts. Part I describes the raw materials—glass, crystals, and metal,—and explains how glass is specified by index and dispersive power. Part II is much the longest. After a brief general survey, it treats of machines and methods for cutting glass and for grinding and polishing plane, spherical, and other surfaces. It then describes methods of testing such as, for instance, the polariscope for detecting strains in the glass, the interference test for plane surfaces, and the spectrometer. Part III consists of three interpolation tables for refractive indices of glass to the fifth decimal place based upon the Hartmann dispersion formula.

Although the author gives a fairly complete treatment of the present practices in German optical shops, an experienced optical worker will find little that is new to him. The tables in the third part seem to the reviewer to be the most valuable part of the book for every day use. Some historical background is given, but almost no bibliography, it being pointed out in the preface that no books had been published before in this field.—H. F. Bennett.

RÖNTGENOGRAPHIE DER METALLE UND IHRER LEGIERUNGEN. *M. C. Neuburger.* Ferdinand Enke, Stuttgart, Germany, 1929. Paper 6½x10 inches, 66 figs., 110 tables. Price 25 RM.

This book is a supplement to "Röntgenographie des Eisens und seiner Lagierungen" by the same author.

It can be stated that it is the most comprehensive and the first complete reference book on the subject. It contains a complete record on the present known X-ray investigations of non-ferrous metals and alloys. The results are presented and discussed on the first 221 pages of the book. Tabulation of data, classified by the various types of lattice and an alphabetic tabulation follow. A bibliographic index will help in the quest for the original investigations.

Metallurgists whose work is devoted to this subject will find in this book a very useful time-saving instrument.—G. Neuendorff.

DAS BETREIBSLABORATORIUM DER METALLGIESSEREIEN UND VERWANDTER BETRIEBE. *W. Claus.* Wilhelm Knapp, Halle (Saale), Germany, 1929. Cloth, 6½x9¾ inches, 88 pages, 154 figs. Price 7.20 RM.

Part 8 of the series on iron, steel and non-ferrous foundry practice, edited by Hubert Hermann.

W. Claus in his book gives an outline of the principles and methods of testing materials as well as a survey on instruments and equipment for plant laboratories. He considers physical testing methods and machines, X-ray equipment, chemical, physical and metallograpnic testing. Most of the 154 figs. illustrate testing equipment and instruments. A list of text books, reference books and periodicals which the library of a testing laboratory should contain is given.

In spite of the brief representation, the subject can be considered as being well covered. Metallurgists who must equip plant testing laboratories will find valuable information, though the book generally deals only with German practise.—G. Neuendorff.

The Engineer's Handbook of Industrial Instruments

M. F. Béhar*

CHAPTER II

Industrial Temperature Instruments

(Continued)

Part 4—TEMPERATURE RECORDERS

1. Scope of Part 4

In the preceding parts of this chapter we covered the *indicating* thermometers and pyrometers used in industry. This necessitated, under each heading, a more or less theoretical consideration of each principle of temperature measurement involved. From now on all theory can and will be dropped. Therefore we shall not repeat the explanation of *how* temperature is *measured* by each class and type of instrument. Nor can we continue to compare the advantages and limitations of each class and type of instrument with reference to its principle of temperature measurement. This part now deals exclusively with temperature recorders *as recorders;* explains how records are obtained; and describes the various kinds of records that can be obtained, and their uses.

2. Advantages of Records

The finest *indicating* thermometer or pyrometer is absolutely useless when not under the eye of an intelligent observer. Practically all of the temperature indicators "in actual use" in industry are *out* of actual use at ninety-nine percent of the time. How apparently extravagant! We even know of thermometers carefully selected and properly installed by competant engineers, and then left to unskilled operatives who don't read them, won't read them, can't read them or ignore their purpose. We—and you, average reader—have seen such thermometers that had become totally useless—broken, black with dirt, covered with dust, coated with whatever substance is used in the process, or otherwise unserviceable. They *had* been used when first installed: the operatives were guided by them at first but in the course of time they cannily learned how to "get by" without maintaining the One Best temperature which is necessary for highest quality or lowest production cost.

The principal advantages of recorders over indicating thermometers and pyrometers are psychological. They relate to the human equation. A few illustrations** will bring out this all-important point. First of all let us repeat that for every process, there is One Best Temperature. Its maintenance depends on some man, whether his job is to work a valve or merely to watch an automatic device. The management generally provides him with the best available means of maintaining the one best temperature—

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*Engineering Editor.

**From this point to the heading "Classification of Temperature Recorders" the author quotes largely from the copyrighted literature of the C. J. Tagliabue Mfg. Co. But since the author himself wrote every word of it while associated with that Company, the inclusion of this matter in this Handbook will no doubt be sanctioned.

but that is not enough. Suppose a batch of material, which was to be processed at 185°F., is found damaged. Of two things, one is certain: either the temperature was maintained at 185°, or it was not. If it was, then the instruction calling for 185° must be revised. If not, then either the mechanical conditions failed, or the man was at fault. There is only one conclusive way to tell—afterward—and that is by the charts of recorders on the apparatus and on the steam line.

But that isn't all—suppose the instructions call for holding at 185° for exactly one hour. Then, if something goes wrong, it is possible that the correct temperature was maintained—but for too short or too long a period. Again, there is only one certain way of telling—and that is by the recorder chart.

In short, the purpose of a record is to tell what the temperature WAS, as well as what it IS.

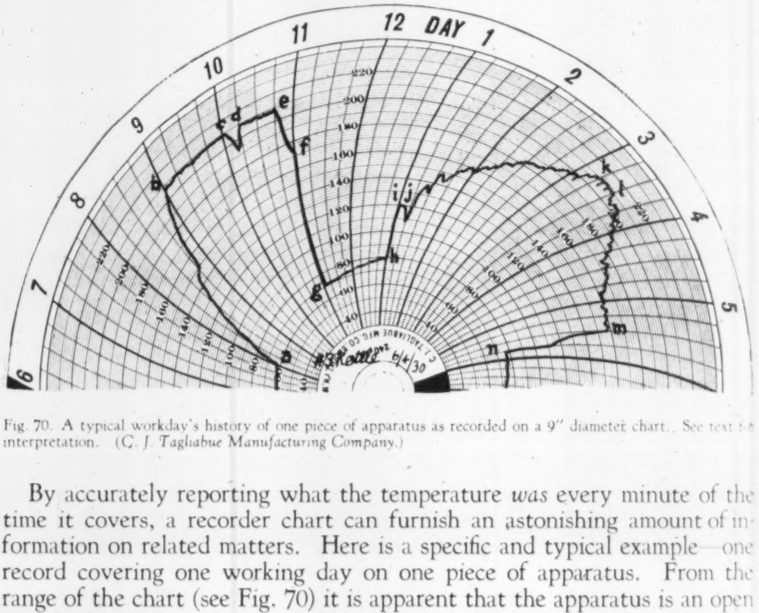

Fig. 70. A typical workday's history of one piece of apparatus as recorded on a 9" diameter chart. See text for interpretation. (*C. J. Tagliabue Manufacturing Company.*)

By accurately reporting what the temperature *was* every minute of the time it covers, a recorder chart can furnish an astonishing amount of information on related matters. Here is a specific and typical example—one record covering one working day on one piece of apparatus. From the range of the chart (see Fig. 70) it is apparent that the apparatus is an open vessel where material is processed in aqueous solution at a boil. Actually it is a dyeing machine. The chart shows that at 8 a. m. (*a*) the steam was turned on to heat the dye liquor in the dyeing machine and the valve so manipulated that the "boil" was reached in one hour (*a-b*) and held for one hour (*b-c*) in accordance with specifications. Steam was shut off for a few minutes while the kettleman took a "swatch" (sample) to the foreman, who compared it with the shade that the mill agent declared would be the fad on Fifth Avenue next season, and ordered another half-hour of the boil. This was done (*d-e*). Steam was shut off at 10:45. The tub was drained in fifteen minutes (*e-f*) and as soon as the bulb (located near the bottom of the tub) was exposed to the air, the pen dropped to the room temperature of 70° (*g*). This was at eleven: by one o'clock the room temperature had risen to 80° (*h*). We next observe a sudden jump (*i*) for the machine was then filled with fresh dye liquor at 120.° This is followed by a drop (*j*) when a batch of material was entered. Another boil then began. Things did not go so smoothly as in the morning. It took two hours to reach the boil temperature, which could only be held for about a quarter-hour (*k-l*). Evidently, the steam failed. The conversations between the kettleman and the boiler house don't show but they can be imagined. At any rate the situation called for judgment, and he used it; in order to make up for the low average temperature, he lengthened the boil, and "the line that cannot lie" shows that he waited until 5:30 before turning off the steam. This action, so clearly reported, saved the material from being badly spoiled. The next day the superintendent read the whole story on the chart in less time than it takes to read it in print.

Too much stress cannot be laid on the idea that when you buy a recording instrument you are investing in a continuous service consisting of truthful reports on some important condition. You are subscribing to a reliable newspaper with a reporter that never sleeps. The value of one year's files of such a newspaper is inestimable. Think of any piece of equipment in your plant, in connection with which temperature must be watched closely. Endeavor to recall the number of occasions when the temperature was too high or too low, what these variations were, and what these variations were, and what the consequences were. If you have no recorder installed on that apparatus, this would be an impossible feat of memory. If, on the other hand, you have a recorder on that apparatus, the complete story is in your chart file—and it probably shows that the fluctuations diminished, because their causes were discovered. A brief fluctuation may escape the attention of a man, but when a recorder is on the job this fluctuation is written on the chart and is there to stay. The man in charge of a process might truthfully report that every time he looked at the thermometer throughout the day it read 150°; but a recording thermometer might show that 150° was maintained throughout the day, except for two periods of fifteen minutes each. In some manufacturing processes this would be quite sufficient to explain a spoilage of material.

Without a recorder, the man in charge would feel sore at being contradicted with no other evidence than spoiled goods, but the chart would prove to his own satisfaction that variations did occur when he wasn't looking.

There are so many chances for arguments in all industries among men who ought to be on the best of terms, that any means of removing some of these causes should be welcomed. This, too, is an important function of the recorder. Many a recorder in service has earned its cost over and over again by preventing discussions.

3. Classifications of Temperature Recorders.

The principal classification follows that of indicating temperature instruments. Thus we have (a) recording thermometers and (b) recording pyrometers. In each of these two divisions one or more groups given under Indicators are here omitted, the reason being that no recorders are made which operate on the principle involved. For example there is no recorder corresponding to the common mercurial thermometer. In general, every indicator provided with a pointer traveling across a scale can be modified into a recorder . . . and has been—the notable exception being the optical pyrometer whose scale-and-pointer indications are meaningless in its present form except when the human eye is used.

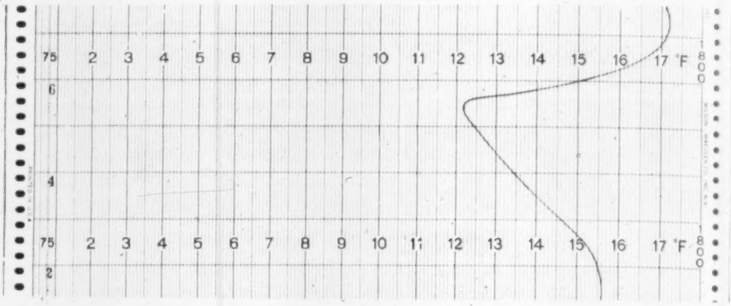

Fig. 71. Single record produced on 12" strip-chart by the pen of a recording potentiometer. Note straight time-lines. Illustration exactly one-third actual size. (*Wilson-Maeulen Company.*)

Recording thermometers are divided into three groups, as follows, and we add references to the discussions of the corresponding indicating thermometers in Part 2 of this chapter, published in previous instalments of this magazine:

(1) *Pressure-Spring* .... March, pages 168-176
(2) *Solid Expansion* .... March, pages 177-178
(3) *Electrical Resistance* .... March, pages 178-182

Recording pyrometers are divided into two groups, and similar references to indicators are given.

(1) *Thermeolectric* .... April, pages 221-224
(2) *Radiation* .... May, pages 317-329

While most of the statements made in Parts 2 and 3, with reference to indicators, are equally true of recorders, there are some exceptions. Minor exceptions will be dealt with under the respective group headings below; one major exception deserves mention here: Under solid expansion indicating thermometers (pages 177-178) we rather depreciated these instruments. The reason is that the majority of the makes on the markets are designed and built for cheapness and ruggedness rather than for accuracy. It so happens that the solid expansion (bi-metallic coil) *recording* thermometers on the market are superior instruments. They are, of course, self-contained instruments. On the other hand, some of the statements made in Parts 2 and 3 are more applicable to recorders than to indicators. As a matter of fact certain classes are made up almost exclusively in recording form (for industrial purposes) and seldom as mere indicators. Examples: gas-filled pressure-spring thermometers, potentiometric thermoelectric pyrometers.

4. Charts and Records.

Before proceeding with descriptions arranged along the lines of the above classification it must be pointed out, as of interest to practical engineers, that from the standpoint of convenience there is another broad classification of temperature recorders: (a) round-chart recorders and (b) strip-chart recorders. Each has its advantages, each its limitations. And right here we must call attention to the erroneousness of the prevalent idea that all industrial recording thermometers (other than electrical resistance) are round-chart instruments and all recording pyrometers strip-chart instruments. *Most* are, but not all. There are strip-chart recording thermometers

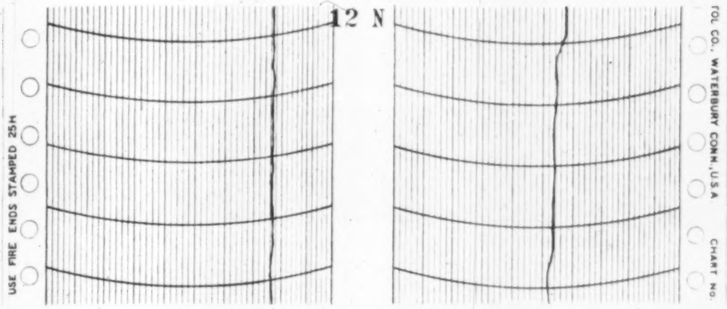

Fig. 72. Strip-chart of a duplex millivoltmeter recorder comprising two moving coil instruments each producing one record. Note curved time-lines. Illustration exactly two-thirds actual size. (*The Bristol Company.*)

available, and some round-chart pyrometers—including the Bristol round smoked chart instrument which has been made for more than a quarter of a century.

All temperature recorder charts are "co-ordinate paper." The co-ordinates are temperature and time. (Transformation-point recorders, dilatometers, etc., requiring other co-ordinates, are not dealt with here). In round charts (Fig. 70) the temperature scale consists of concentric circles and the time divisions are "curved radii" or arcs whose curvature must correspond exactly to the path followed by the pen when swung. In strip charts the equal-temperature lines of the temperature scale run lengthwise, and the time-division lines run crosswise. These latter are curved (Fig. 72) when the record is made by the end of the galvanometer or thermometer pointer which swings in an arc. They are generally straight (Fig. 71) because most recording pyrometers embody a rectilinear writing or printing device.

Charts are generally made of tough ledger paper. Parchment paper and other materials are also supplied. All manufacturers specify non-hygroscopic chart stock when buying their supplies. This is important because recorders are calibrated for standard printed charts with temperature scales of definite length. If the paper stretches, the temperature scale lengthens, and the temperature record is "off." Some electrical recording instruments (pyrometers and resistance thermometers) are supplied with translucent charts—the record being printed on the under side. The reason for this is generally that the instrument is so designed as to expose as much of the chart to view as possible and make the record legible without delay.

Some strip-chart instruments have an indicating scale running horizontally at the top—above the "now" portion of the strip chart. Round-chart instruments as a rule are not provided with such a scale—the scale on the chart serves as well and the pen-arm thus serves as the indicating pointer. (A notable exception is the new Uehling combination indicator and round-chart recorder described below). We have used the expression "pen-arm." It is so called in the non-electrical thermometers. In the electrical round-chart instruments it is usually called the pointer: it does not end in a fountain-pen and the record is produced otherwise than by "writing," as will be explained below. (Again the Uehling round-chart potentiometer recorder is an exception. It has a fountain pen.).

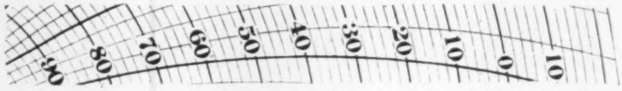

Fig. 73. Exact size reproduction of portion of round chart, 9″ diameter. Note "reverse" scale. (*C. J. Tagliabue Manufacturing Company.*)

Chart Scales and Sizes

Round Charts—The length (in inches) of the temperature scale on a round chart is necessarily less than half the diameter. In general, the low end of the scale is near the center and the upper end toward the rim. A space of about half an inch is allowed at the rim for the time graduations, and at the center there is a circular space for chart number, maker's name and notations. If the scale were to extend very close to the center the time divisions would be so close together as to impair the value of the records. This brings up the subject of selecting the proper range for a recorder: In addition to what was said above on this subject (in connection with indicators) it is well to point out that the most easily read portion of a round chart is toward the *outer* edge. An important case in point is a refrigerating application. The temperatures of greatest interest are those in the lower portion of the scale. Therefore it is well to specify a recorder with "reverse" chart—the low end of the scale on the outside and the upper end on the inside—as illustrated in Fig. 73.

The larger the round chart the longer the scale; but the longer the chart the larger the recorder itself—and, of course, the higher its first cost. Inevitable! Also, a few dollars more for your plant's monthly chart supply. Some engineers argue, "What's the use? The larger size has the same movement with a longer pen-arm. It's no more accurate." Wrong! Not only is a longer scale conducive to better temperature control but the larger size recorder (of the same make, say) is itself a better instrument. Let us explain why: The instrument is no better in design, no better in materials used, but it is better in its final details of construction and calibration. Just as it is easier for the user to read to the fraction of a degree on the larger scale, so is it easier for the men who complete its manufacture, down to the final inspector: they can "see better" the effects of their manipulations and adjustments.

It all depends on the application. In some oil refineries the superintendents will not consider recorders smaller than 12″ chart diameter. On the other hand a handy light-weight self-contained recorder, like the new Bristol 4″ chart "miniature" instrument, for example, finds eager markets in various industries.

Recorder "size" does not always mean chart diameter—the latter being invariably *smaller* when there is a discrepancy. This regrettable method of listing and advertising goes back many years. Don't blame the present instrument company officials: with every new model they are gradually abandoning this awkward practice wished on them by their fiercely competing fathers. As a matter of fact the logical "size" would seem to be the length of the scale. Of two charts, each 9″ diam., one with a 3½″ scale will provide more legible records than one with a 2½″ scale.

Fig. 74 shows a full-size section of a 12″ diam. chart, the scale of which (not shown fully owing to our page width) is 4¾″ long. We have selected

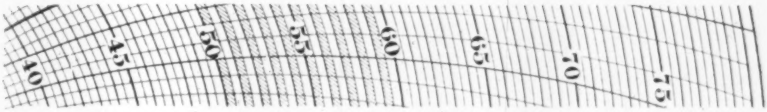

Fig. 74. Exact size reproduction of 12" dia. round chart. Scale length is $4\frac{3}{4}$". Note accentuation of the zone between 50 and 60°. (*C. J. Taglіabue Manufacturing Company.*)

this particular chart for illustration here because of the emphasis on one temperature "zone." A few years ago there were no such distinctive charts; today several recorder manufacturers are creating dozens for the benefit of various industries where process temperature are standardized.

Strip Charts—The scales of strip-charts run from left (low) to right (high)—usually *zero* at the left edge. And right here we have the main difference. Practically all strip-chart recorders are electrical instruments—the majority being recording millivoltmeters and only three being recording potentiometers. Chart width is only one of many factors. A manufacturer of round chart recording thermometers may make four sizes but each electrical strip-chart recorder manufacturer has selected one standard chart width for each type of his instruments. Another thing: various makes of, say, gas-filled bulb-tube-and-spring systems are so similar that fewer than a dozen men can tell them apart, but the various makes of electrical temperature recorders are strikingly different from one another in their inner design and construction. The high versus low resistance controversy was dwelt upon* in connection with millivoltmeter indicators. It is only one point of difference. Among others are the several methods of compensation for various effects, also described. In millivoltmeter recorders the problems are intensified and it must be emphasized that every millivoltmeter recorder is a series of compromises. Pen-arm length, for example, is a trifling matter with a powerful pressure-spring, but pointer *weight* (increasing approximately as the *square* of the scale length) is a perplexing design factor in millivoltmeters. You can't say, "Other things being equal I want a strip chart with such-and-such a scale." Other things *can't* be equal.

Yes, electrical temperature recording installations need more attention and maintenance than the others, but they possess important advantages, among them multiplicity of records, as was mentioned under indicators and will be discussed below. Having decided that your application needs records produced from (a) electrical resistance thermometer bulbs, (b) thermocouples or (c) radiation receivers, and that you prefer such records on strip charts, the next step should not be to select the best-looking or most convenient chart, but the most suitable *type* of recorder—the type depending on the method of temperature measurement as described in Parts 2 and 3 of this chapter. As to *make*—do not rely on this Handbook.

Chart Speeds

The rate of motion of a chart corresponds to that of the recorder clock mechanism. In recorders with round charts this speed is expressed in terms of revolutions. A "24-hour" chart is one designed for use in a recorder which revolves it in that period.

Some standard revolutions for round-chart recorders are 4, 6, 12, 24 and 48 hours, and seven days. These and other clocks are carried in stock by recorder manufacturers. It is possible to change from one chart speed to another by changing clocks. This is a simple matter in some cases but it always requires extreme care in the final positioning of the chart axis with reference to the pen-arm pivot. The majority of recorders revolve their charts counter-clockwise, so that a clockwise record is produced.

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*INSTRUMENTS, April 1930, pages 225-226.

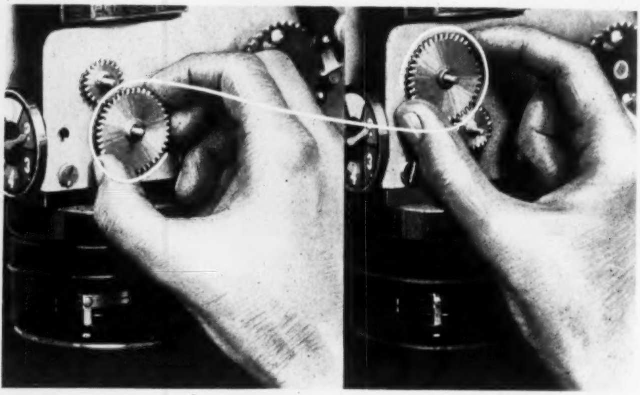


Fig. 75. Illustrating (1) changing chart speed by shifting gears; (2) multiple-switch and colored indicating dial showing which couple is recording. (*Brown Instrument Co.*)

Strip-charts come in rolls, usually a little over 20 yards long. This makes 720 inches. The standard hour-line spacing is one inch, so that the usual chart is a one-month roll (32-days in some cases). One inch per hour is the standard rate of strip-chart motion—the direction of which is always downward for convenience so that the record reads "up". The mechanism of some strip-chart recorders lends itself to changing of chart speed. Fig. 75 shows how this is done in the Brown recorder. The Esterline-Angus Co. make electrical recorders with a *magnetic* gear-shift for chart speed.

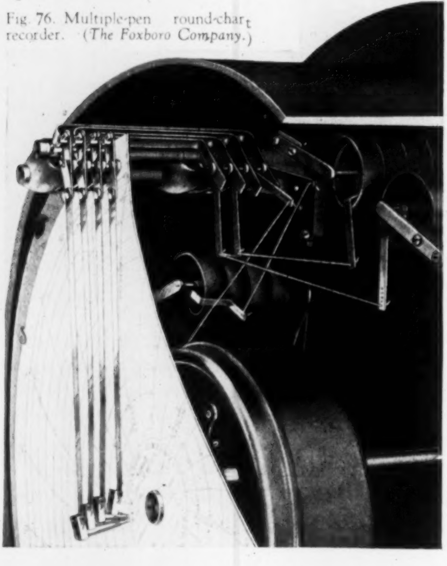


Fig. 76. Multiple-pen round-chart recorder. (*The Foxboro Company.*)

Multiple Records

It often is desirable to obtain two or more records on one chart. In most industrial cases of this kind the need is for a temperature record together with a record of CO_2, or other processing condition or measurable magnitude. These we may designate as "combination records." By "multiple records" we mean two or more temperature records. This nomenclature is not official, and is hereby proposed as convenient to all concerned.

A multiple record implies a plurality of primary elements such as bulbs or thermocouples. Pressure-spring thermometer bulbs are permanently connected; hence their records are continuous. Resistance thermometers bulbs, thermocouples and radiation receivers are usually connected successively; hence their records are discontinuous, but the impressions are usually close enough together as to make each individual record as satisfactory as a continuous line for all practical purposes. Note that the several primary elements connected to one millivoltmeter or potentiometer must have the same temperature-emf relation. For example, a base-metal couple should not be connected to a millivoltmeter whose scale has been calibrated in degrees corresponding to the emf curve of a rare-metal couple.

Round Charts—Non-electrical recording thermometers may be made up with two or more pens, each actuated by a spring connected to a bulb. The "tube systems" need not be of the same class and the bulbs may all be be different, but the range of each must be within the chart range. As a rule, therefore, the tube systems *are* of the same class. Each is quite independent of the others. The practical limit in regular instruments is four pens—great number being "specials." All pens are mounted coaxially as shown in Fig.76. Each pen being continuously in contact with the chart, a dilemma is presented: either all pens are on the correct time arc (in which case they cannot cross), or else the pens can cross one another but in that case, all but one are either too long or too short. The result, in the latter case, is that an event affecting all pens at the same time, and immediately registered by four pens, for example, will show up as a record of four successive events, separated by time intervals which vary inversely with the distance of each pen from the center of the chart at that particular moment. In other words, a $\frac{1}{16}''$ linear departure which shows up as a five-minute time-error six inches from the center of the chart will appear as a fifteen-minute time-error two inches away from the center. This unavoidable effect is generally negligible, and can be remembered in interpreting the multiple records so produced.

Strip-Charts—As many as sixteen temperatures may be recorded electrically on one strip-chart, by one method, without difficulty and without inevitable confusion. The methods vary. Some mechanisms will be briefly described below under various electrical recorders.

One method does not depend on commutating devices but on a plurality of millivoltmeters (two or three) arranged side by side, each writing a continuous record on its own part of the chart. (Fig. 72). With this arrangement each millivoltmeter can be connected to a primary element of a class different from the other or others. One may record the temperature of a resistance bulb while another records the temperature of a thermocouple(We might call such recorders "duplex" or "triplex" and reserve the adjective "multiple" for a single meter commutating to a number of primary

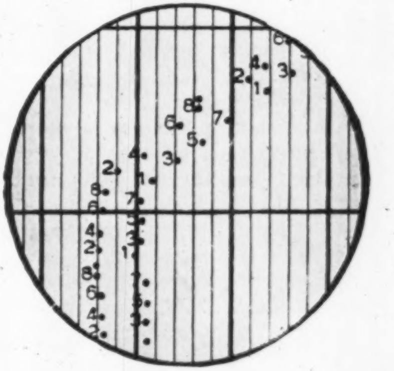
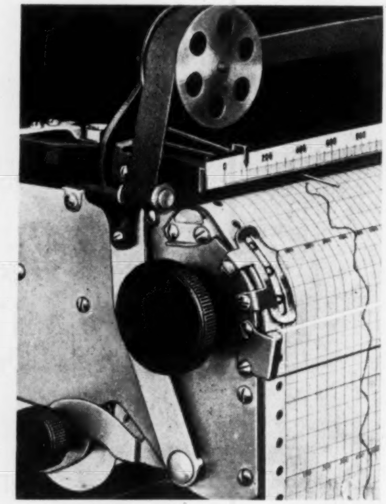


Fig. 77. Exact size portion of chart taken from multiple-point recording potentiometer. (*Leeds & Northup Co.*)



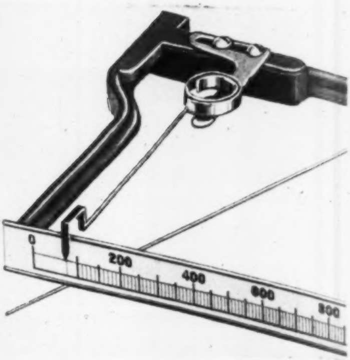


Fig. 78. Detail of a ribbon-printing strip-chart recorder in which the ribbon is moved back after each impression. Cut also shows index for setting chart at correct time. (*Brown Instrument Company.*)

Fig. 79. Showing scale, depressor bar, and open circuit starting point for pyrometer strip-chart recorder. (*Brown Instrument Co.*)

elements, but the term duplex is already used to designate a double recorder—two meters, two charts, one clock, one printing ribbon, etc., all in one.

The various commutating methods involve an automatic multiple-switch which connects up the several primary elements in rotation. In addition to this switch there usually is an arrangement, working simultaneously, for identifying the various records. Each make has its own ingenious mechanism. There are threads of different colors, ribbons of two or more colors working like the familiar two-color typewriter ribbon but automatically shifting, print wheels with keys like typewriter keys which print dots or asterisks *and* identifying numbers alongside of them, arrangements whereby various records consist of dots or dashes or distinctive combinations, etc.

Such records being discontinuous, it is well to remember that the greater their number, the longer the time-interval between two successive impressions on each of the records. This time-interval for any one of sixteen records on a 16-point recorder whose period is one minute will be sixteen minutes. On a chart traveling at the customary speed of an inch an hour the corresponsing distance would be about a quarter-inch. This is worth bearing in mind. As a rule, therefore, multiple-point recorders are of the greatest value for processes of long duration involving gradual temperature changes with no possibility of sudden temperature changes, and in which temperatures differ but are always in the same proximate relationship.

A bus-bar board is a useful accessory. It performs about the same duty for a multiple-point recorder that a selector switch does in an indicating system. When there are more thermocouples (or resistance bulbs or radiation receivers) than recorder points, the operator selects those to be recorded, and by plugging them in on the bus-bar board keeps the records of the ones desired. Or, the operator may plug in any one thermocouple at two or more points to secure a more frequent recording.

In addition to the identification of multiple records on one chart, the recorder may be provided with a device indicating which primary element is connected at any time. (Fig. 75).

Chart Ranges

With recording thermometers the chart ranges need not start at a zero imposed by the characteristics of the measuring system. There are hundreds of stock charts to choose from, (long and short in degrees as well as in linear length of scale) and with convenient high and low points. Each class of system has its range limitations, and the vapor-pressure class, in addition, generally requires very "progressive" charts—with graduations much closer together toward the low end than at the high end. Therefore it is well to choose a range in which the temperature of greatest interest will be near the top . . . *if* the application is not one where the temperature may occasionally rise so much higher than the upper end of the range that the system will explode.

Millivoltmeters give the best indications toward the upper end of the range—say between 65 and 85 percent of the total deflection. This has nothing to do with legibility of records on strip charts but with the selection of the range itself.

Bi-metallic coil recording thermometers come in several convenient ranges. Characteristics have been given above.

With thermoelectric pyrometers it is best, as a rule, not to specify a suppressed-zero range. The reasons are stated below under electrical instruments.

5. Portable and Wall Models.

Another broad classification of temperature recorders has reference to the availability, in addition to the usual wall models, of portable and of self-contained instruments. Not all self-contained recorders are portable; nor are all portable recorders self-contained. A portable instrument, when not self-contained, has a provision for neatly coiling up the connecting tube, and the whole outfit may or may not be carried in a special additional case. Any self-contained recorder can be carried from place to place, and to make it into a portable instrument all that is needed is a handle and (if round-case) a pair of legs. We refer, of course, to industrial instruments: A Weather Bureau "Thermograph" is self-contained but not portable.

In the following list the letter W stands for "distance" wall model, P for portable with flexible tubes and bulbs, and SC for instruments with no connections outside the case (Note that the sensitive *bulb* of a self-contained recorder may protrude outside the case when it is desired to make the latter dust- and moisture-proof).

RECORDING THERMOMETERS

(1) Pressure-spring			
Mercury	W	P	SC
"Xylene"*	W	P	SC
Vapor-pressure	W	P	SC
Gas	W	—	—
(2) Solid Expansion	—	—	SC
(3) Electrical-Resistance	W	—	—

RECORDING PYROMETERS

(1) Thermoelectric	W	P	—
(2) Radiation	W	--	—

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*Meaning *all* liquid-expansion systems utilizing liquids other than mercury. Xylene is used in more than 90% See March instalment, pages 169, 170.

6. Recording Mechanisms.

Purposely, the foregoing pages have been devoted to the importance of *records*, to their various forms, and to broad classifications of the industrial temperature recorders. It is in these things that engineers using this Handbook for practical purposes are primarily interested. The construction of various makes, while of equal interest to recorder users, cannot be gone into here, except incidentally as illustrating the subject at hand, which now is the construction of the various classes and types.

Considering temperature recorders as temperature instruments, we classified them above into thermometers and pyrometers, with "groups" within these two divisions. Considering them now as recording instruments (which we must in a discussion of mechanisms) we find that they fall into a different classification:

Non-electrical	(a) Pressure-spring (b) Bi-metallic spring
Electrical	(c) Millivoltmeter (d) Potentiometer

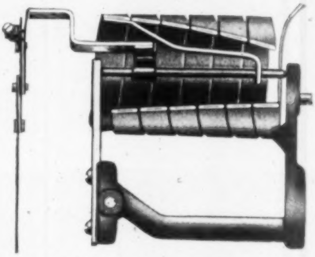


Fig. 80. Helical form of pressure spring, showing method of actuating pen. (*The Foxboro Company.*)

Following a classification according to principle of temperature measurement would lead to useless repetitions and possible confusion.

The basic idea of a recorder mechanism is simplicity itself: a chart moving in one direction, say vertically with time, and a pen moving across it with degree of temperature. The chart is moved by a clock; the pen hangs on the end of a pointer; the pointer swings with temperature. The practical utilization of this idea by inventive genius for the service of industry is a fascinating subject. Space restriction prevents doing it full justice. Moreover, since most recorders of the same class look alike on the outside (a square, round or pear-shaped case with a glass door through which you can read the chart) space will be saved also by omitting outside views with the single exception of a new instrument, of which the first announcement appears at the end of this article.

(a) Pressure-spring

This group comprises the great majority of recording thermometers, and is divided—exactly as in the case of indicators—according to the "fillings" of the "systems," into four classes, to the characteristics of which eight pages were devoted in Part 2. This went into considerable detail not only with reference to temperature measurement, bulb materials and volumes, tube lengths, etc., but with reference to uniform and progressive scales and other topics affecting recorder design and construction.

By far the most important recorder design factor arises from the necessary use of printed charts. *Every* recorder using a certain chart must have a pen travel, with regard to temperature, exactly like that of the others. Accuracy is not enhanced by individually calibrated scales, each hand-made for one movement, but by individually calibrated movements, each adjusted to the same given scale. Hence we find that on the one hand various parts are quantity-produced with a high degree of uniformity, and on the other hand the design is such as to make a number of adjustments possible not only at the factory but in service.

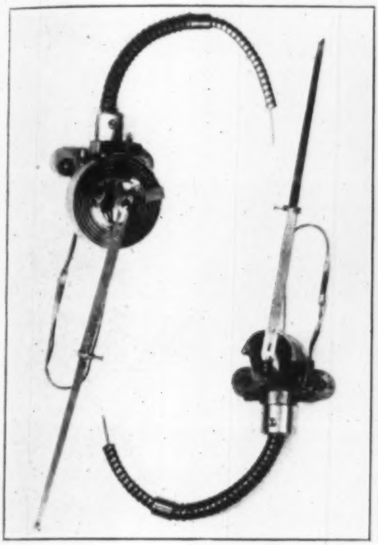


Fig. 81. Two forms of gas filled system movements, complete with pens. (*The Bristol Company.*)

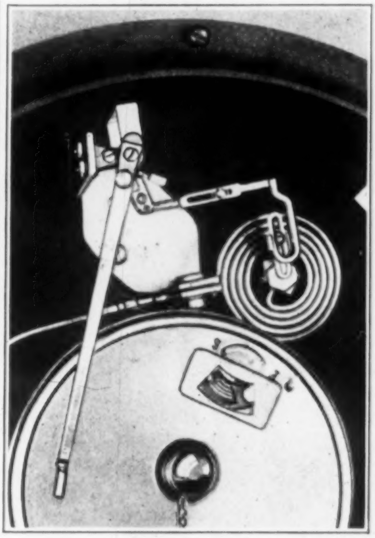
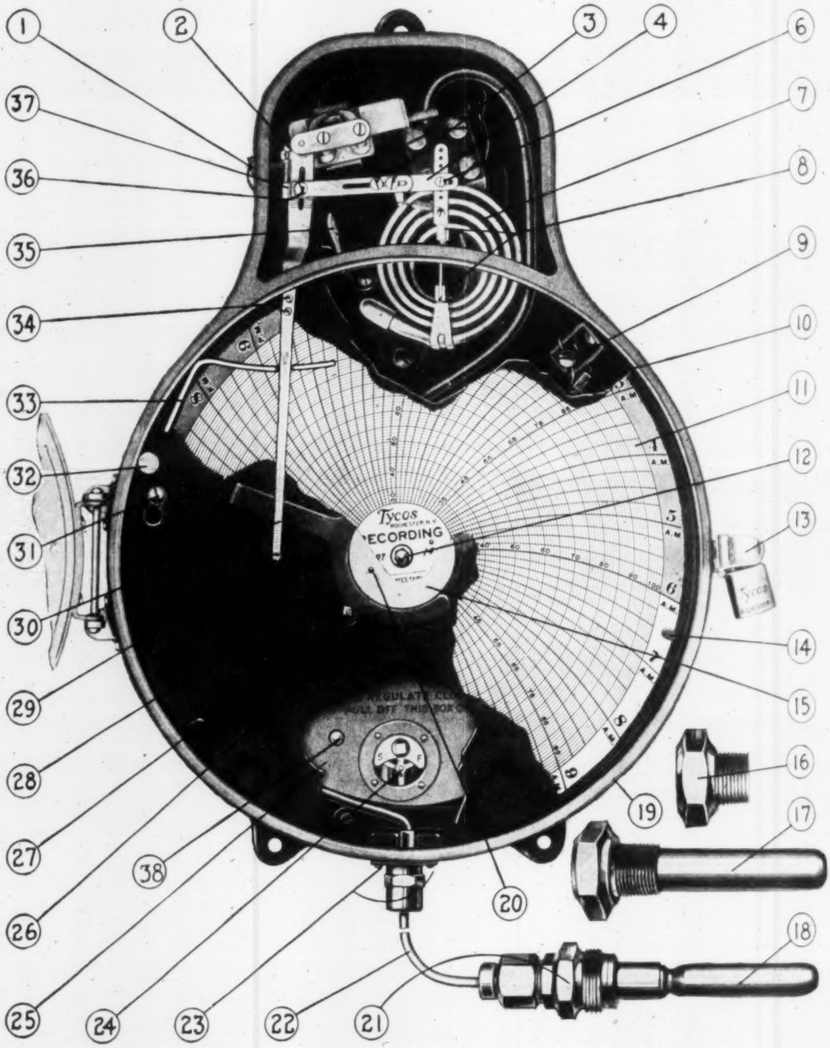


Fig. 82. Mechanism of a mercury system recording thermometer. (*C. J. Tagliabue Mfg. Company.*)

Whether on account of differently trained personnel, or for some other reason, users of pressure-spring recorders will not even tolerate "constant" errors such as are not objected to by recording pyrometers users. Some manufacturers therefore provide several adjustable links and other features whereby it is possible to correct not only for errors in temperature indication but for agreement of pen travel with time lines, etc.

Figures 80-82 show the "evolution" of the pressure-spring indicating thermometer into a recorder. Fig. 80 shows a spring (helical in this particular example) actuating a pen-arm which might as well be an indicating pointer, for no clock or other recorder appurtenance is shown. It belongs, however, to a recorder—a self-contained recorder for atmospheric temperature. The tube end visible in the upper right corner is used for filling, and then sealed. Fig. 81 shows two styles of gas-filled movements. The longer spring, which deflects more per degree of temperature change, is used for short chart ranges; the shorter spring for long chart ranges. Fig. 82 shows a mercury-filled system movement. Note the U-shaped bi-metallic compensator for fluctuations in temperature around the head of the system. Note also the recorder clock—a spring-driven time-piece, which is the usual practice in pressure-spring recording thermometers. Fig. 83 is a cut-away view of a complete mercury system recorder of a representative make, the following detailed description of which brings out all essential features found in all recorders of this class, and some applying to other industrial pressure-spring recorders.

Operation—The movement of the heat-treated and seasoned coil 9, which opens or closes as the temperature at the bulb 18 increases or decreases, is transmitted (by link 4) to pen arm 30, and pen 29 is thus moved radially over paper chart 11, which is revolved by clock movement 25. The link 8 is a bi-metallic strip which automatically compensates against erroneous indications due to fluctuating temperature around the case. This simple arrangement has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Tycos
ROCHESTER N.Y.
RECORDING
REGULATE CLO
PULL OFF THIS BOX C
A.M.

Fig. 83. Complete mechanism of a mercury filled recording thermometer. (*Taylor Instrument Companies.*)

the following advantages: (1) The pen arm is always pivoted at the correct center relative to the radial lines on the chart, thus insuring correct time reading. (2) The pen 30 always has the same bearing pressure on the chart, just sufficient to make the ink flow freely. (3) The pen is less affected by vibration when the pen arm is pivoted on a rigid support.

There is little friction in the movement, but if increased many times it would have no effect on the accuracy of the indication, because the power developed by the coil is greatly in excess of that required to actuate the pen 30 against any small friction that may exist. A stop 35 prevents the pen from operating within the inner circle of the chart.

Calibration—At times a recording thermometer may get slightly out of calibration, due to long-continued use, or to being subjected to unusual strains or rough handling. This means that the instrument does not record correct temperatures, and *the error is not constant at all points on the chart.* Micrometer screw 2 permits moving a slide-plate 4 up or down in the slot of the pen-arm support, thus furnishing a means of calibrating the instrument easily. When the slide plate 4 has been moved to the correct position, at which time the pen will record correctly at each point across the chart, the screw 36 is tightened, holding slide-plate 4 in a fixed position. This pen-arm support is graduated every five turns of the calibrating micrometer-screw. Thus a new tube system may be constructed and calibrated, forwarded to the user with accompanying marked diagram, and be reinstalled by the user, without the necessity of recalibration. This is of particular importance to large users of recording thermometers, who maintain central testing laboratories.

Time Index—When a new chart is inserted this small index, which is permanently attached at the position of the pen point when at the outer edge of the chart, makes it possible to set the chart accurately, whether or not the pen point rests on the surface of the chart. Also it helps determine at a glance the duration of a specific and essential time period.

To Remove Chart—Remove quick-turn chart hub 12, depress plunger 32, which lifts pen arm by means of lifter 33 and simultaneously ejects chart from center arbor and clips, by means of forked ejector 26 and leaves the recorder free for clock winding and the insertion of a new chart.

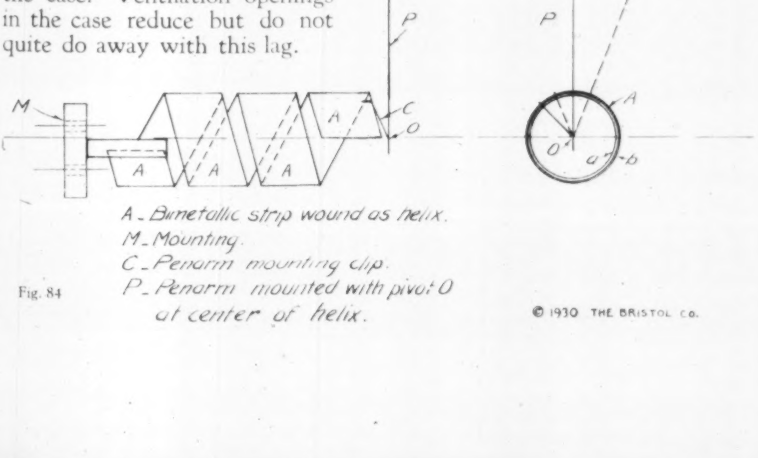
To Insert Chart—Place chart in position with arbor through the center hole. Set chart for time by use of index, replace chart hub and slip edge of chart under clips 14.

Clock Movement— . . . is provided with a regulator 24, to accelerate or retard its action; and a starter 38 to start clock if necessary.

Case—The door is mounted on a spring hinge, so that when closed and fastened by a spring latch, the felt packing is compressed tightly against the edge. This feature becomes an important factor when a number of charts are to be changed each day, and provides a moisture-proof case, necessary to protect the mechanism.

(b) Bi-metallic Spring

These recording thermometers are self-contained, of course—the spring being the primary element and being directly connected to the pen-arm. Fig. 84 shows the principle. These instruments are used for recording atmospheric temperature. They could be used in drying ovens, etc., but long exposure to moderately high temperatures, while having no harmful effect on the metallic parts, and while not sufficient to injure the charts, would nevertheless gum the droplets of lubricants which are necessary in all clocks and other movements. Being individually calibrated for their charts after assembly, they are satisfactorily accurate — which seldom can be said of the indicators utilizing the solid expansion principle. The spring being enclosed in the case, this class of recorder should not be used for rapidly-varying temperatures because of the thermal capacity of the case. Ventilation openings in the case reduce but do not quite do away with this lag.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P
P
M
C
O
A
A
A
A
A
O
a
b
A - Bimetallic strip wound as helix.
M - Mounting.
C - Penarm mounting clip.
P - Penarm mounted with pivot O at center of helix.

Fig. 84

© 1930 THE BRISTOL CO.

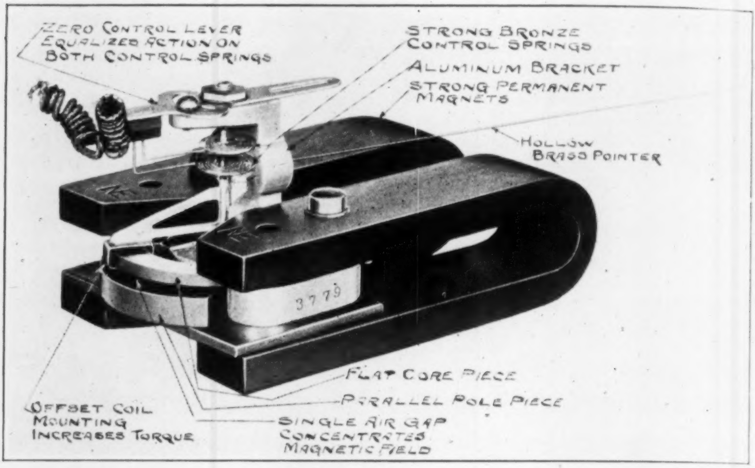
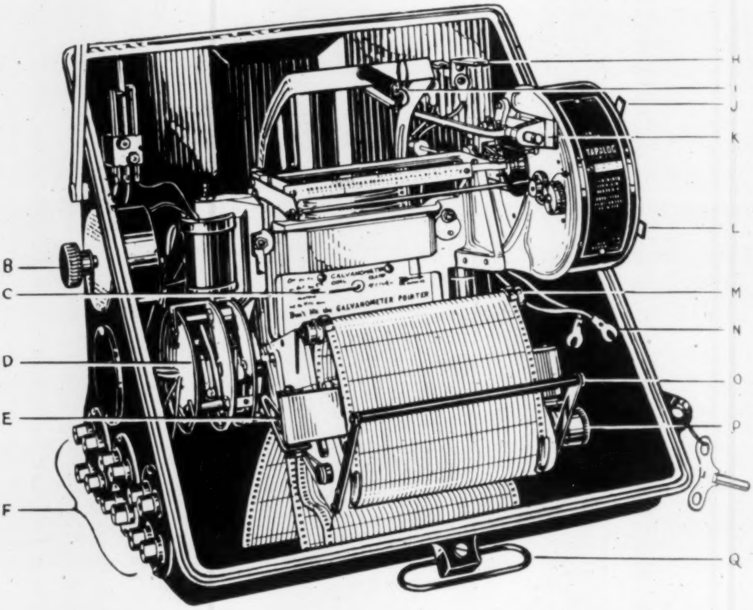

ZERO CONTROL LEVER EQUALIZES ACTION ON BOTH CONTROL SPRINGS
STRONG BRONZE CONTROL SPRINGS
ALUMINUM BRACKET
STRONG PERMANENT MAGNETS
HOLLOW BRASS POINTER
3779
FLAT CORE PIECE
PARALLEL POLE PIECE
OFFSET COIL MOUNTING INCREASES TORQUE
SINGLE AIR GAP CONCENTRATES MAGNETIC FIELD

Fig. 85. Moving coil electrical instrument of a recording millivoltmeter. (*Thwing Instrument Company.*)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GALVANOMETER
Don't lift the GALVANOMETER POINTER
M
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D
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P
F
Q

Fig. 86. Tapalog recording millivoltmeter. B. Rheostat for adjusting automatic electric compensator. C. Lever for clamping galvanometer coil. D. Multiple switch with cover removed. E. Printing ribbon and ribbon spool. F. Binding Posts for connecting thermocouple leads. H. Terminal connections for dry cell for Automatic Electric Compensator. I. Spring support hook for supporting carriage. J. Start & Stop lever of clock. K. Adjustment screw for adjusting mechanical zero of galvanometer. L. Fast & Slow lever of clock. M. Back roller of paper carriage. N. Connection terminals for series of three dry cells operating recorder. O. Carriage support bar. P. Front roller of paper carriage. Q. Latch for fastening cover. (*Wilson-Maeulen Co.*)

(c) Millivoltmeters

The measuring circuits of resistance thermometers and of thermoelectric pyrometers have been described in Parts 2 and 3, as well as the principle of radiation thermometry. Indicating millivoltmeters were also gone into. Of recording millivoltmeter *movements* it need only be mentioned that they are generally more rugged than the corresponding indicating movements by the same manufacturers. Under indicators there were illustrated various makes, and the features of others were mentioned. One finds a corresponding variety of types in the recorders. Fig. 85 shows one special construction for use in a recorder. It is selected to illustrate this section, because that particular make (Thwing) was not mentioned at all under indicators. An interesting feature is that the weight of the coil balances the pointer, the down-bent tip of which is automatically inked by being depressed, between recordings, into a capillary-fed ink-well at the zero position of the pointer. The records are made by causing the pointer to touch the chart paper, the means employed being a depressor-bar above the pointer.

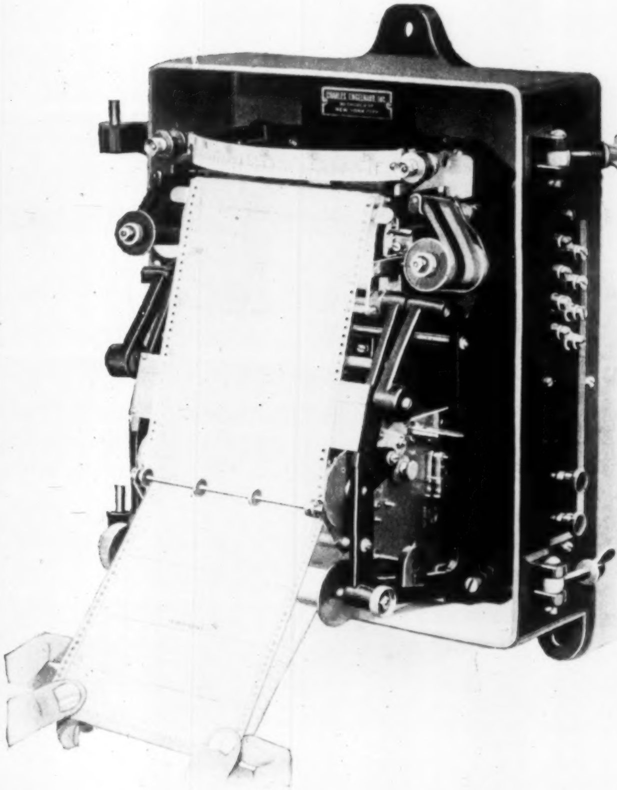

Fig. 87. **Mechanism** of multiple-recording millivoltmeter. Note the multi-colored ribbon. The moving coil is of the double filament support type; the clockwork is spring driven; the dots are regularly spaced one minute apart but this can be increased to four per minute. Standard chart speeds are $^3/_4''$ and $1^1/_2''$ per hour. Chart is automatically re-rolled as used but can be pulled back as shown. (*Chas. Engelhard, Inc.*)

This depressor-bar (also called chopper bar) is found in practically all recording millivoltmeters. It stays up, and allows the pointer to swing to its indicating position, at all times except at the moment of recording, when it comes down and presses the pointer against the chart. In some instruments, as in the one just described, the pointer itself is inked; in others the pointer makes a white dot on a smoked chart (which later is "fixed"); in others the pointer carries a tiny ink capillary; in others it presses a translucent chart against carbon paper. In these types the time lines are arcs, whether the chart is round or strip. In other instruments the pointer itself, when pressed by the bar, in turn presses the chart paper against an inked thread or ribbon. Bar and ribbon are straight, and so are the time lines on the chart. Fig. 79 shows such an arrangement, also two other features: depressor bar combined with indicating scale, and cold junction compensation index (for thermoelectric pyrometer use) showing proper zero position of pointer on open circuit.

Figs. 86 to 88 bring out other features of recording millivoltmeters.

Needless to say, millivoltmeter *recorder* installations include all the modern features of temperature *measuring* millivoltmeters circuits.

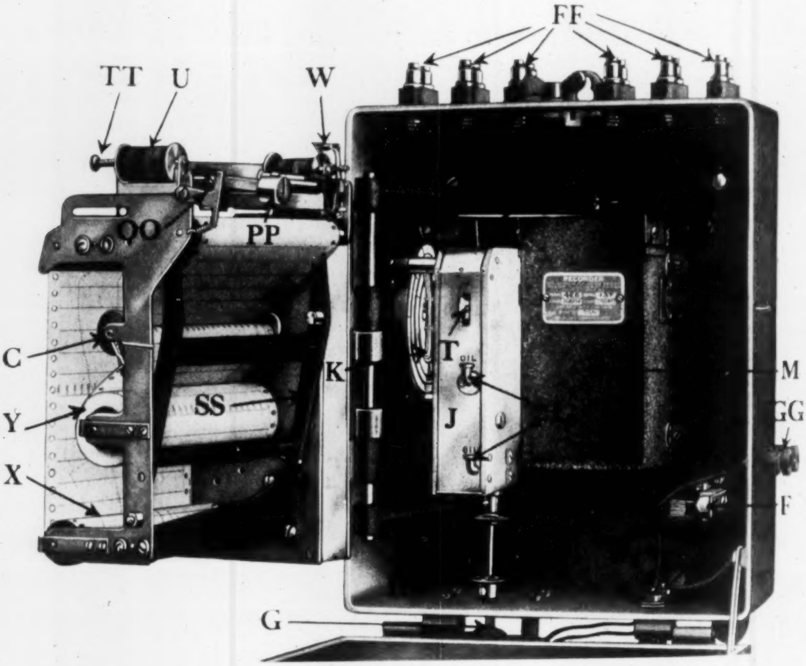

Fig. 88. Multiple-point Pyrometer Recorder. A. Eight-day clock. B. Clock speed regulator. C. Automatic paper tension device. D. Clock start and stop button. E. Chart drive-roll. F. Clock element latch. FF. Thermocouple binding posts. G. Electric motor. GG. Electric motor binding posts. H. Motor drive shaft. J. Speed reduction transmission case. K. Self-cleaning automatic multiple switch. L. Oil cups. M. Weston millvoltmeter movement. MM. Millivoltmeter pointer. N. Zero adjuster. O. Boom actuating lever. OO. Automatic boom lifter. P. Indicating scale and boom. PP. Boom counterweight. S. Ribbon carriage. SS. Ribbon carriage frame. T. Carriage cam shoe. TT. Ribbon rewind knob. U. Multi-colored ribbon. W. Ribbon drive ratchet. X. Rewind chart roll. Y. Stock chart roll. (*The Bristol Company.*)

(d) Potentiometers

Now we come to real *machines:* potentiometers are to millivoltmeters what sensitive scales are to spring balances, and recording potentiometers correspond to modern automatic and autographic scales—which in fact they surpass in ingenuity of mechanisms.

The simple potentiometer circuit was explained above in connection with thermoelectric pyrometry. It was brought out that the opposing emf must be manually regulated by the observer until the circuit is balanced, when the reading is taken with no current through the sensitive galvanometer, which then is undeflected—its needle at zero which is at the center. This regulation of potential is effected by moving a brush along a slide wire resistance. The position of the brush on the wire gives the temperature.

Now, the main requirement in the problem of designing a recording potentiometer is to make it self-balancing: whenever the galvanometer needle starts swinging to the right, the brush must be moved up the wire and scale; when it swings to the left, the brush must be moved down. Since brush motion must be proportional to needle deflection the needle itself is made to control a source of power which moves the brush.

Instead of moving the brush, the wire itself may be moved.

Instead of rectilinear motion, rotation may be imparted.

The same motion can readily cause a pen to travel across a chart: with ample power available, friction is immaterial.

But the main problem is to utilize the feeble deflection of a needle, which a feather-touch or even a breath can seriously affect.

Between 1897 and 1905 several European scientists solved this problem and made up self-balancing laboratory potentiometers. It remained for American genius to produce industrial recording (and controlling) potentiometers. The first one was the Leeds and Northrup, for which the first patents were taken out in 1909 and which was fully developed within a few years to its now familiar form. The second was the Wilson-Maeulen (1929). Only these two were mentioned under potentiometers in Part 3. Since the publication of that instalment a third—the Uehling—has been brought out (May, 1930) and it is our privilege to present below its first public description.

Descriptions of the action of the three recording potentiometers now follow. The manufacturers' nomenclatures will not be changed.*

(1) *Leeds & Northrup.*

The relation of the instrument (the galvanometer) to the machine is strikingly brought out in Fig. 89. The galvanometer assembly (filament-suspended moving-coil, magnet, etc.) is shown held above its normal place. This suggests independence or interchangeability, which is also a feature of several modern industrial millivoltmeter recorders but with the important difference that you can't interchange the moving coil, the magnet, or both, in a millivoltmeter without having to re-calibrate, whereas in any potentiometer the calibration is not affected. In L & N literature where this same photo appears the caption says that the "sensitive directing finger" is easily removed and replaced. Good name!

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*It seems to the author, however, that it might be a good idea, in speaking of electrical instruments, to use the term "needle" in connection with a detecting galvanometer, and "pointer" in connection with a measuring system. This may appear trivial until one remembers that the needle of the galvanometer in a true null-method potentiometer does not travel over a temperature scale. Its function is to indicate a state of unbalance. True, this state of unbalance is proportional to temperature variations, and in the semi-potentiometer the "galvanometer" is provided with a scale graduated in degrees of temperature. In that case, we believe, the moving-coil system should not be called a galvanometer but a millivoltmeter.

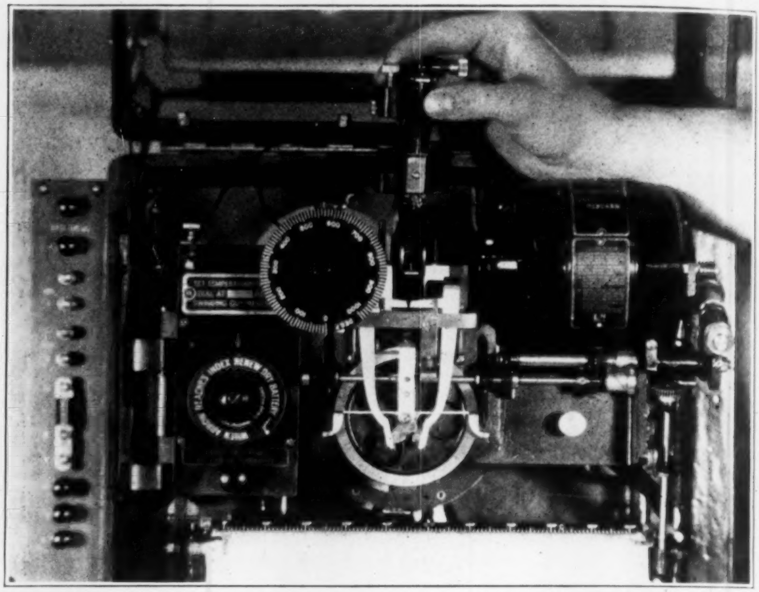

Fig. 89

If the reader has never seen an L & N recorder, Fig. 89 seems at first glance to represent a complicated mechanism, and Fig. 91 might make him give up the desire of studying it. Don't give up—compact it is, but not complicated. The action is simple and can be understood without going into minor details of construction. Fig. 90 shows the entire mechanism whereby the deflection of the "directing finger" is made to balance the circuit so that the galvanometer is undeflected when a record is made on the chart.

Mechanical power has to be employed. It comes from the motor shown under the man's wrist in Fig. 89, and passes through the worm gear train, also visible in that photo, to shaft 6. The galvanometer system 7 swings about the vertical axis 7S. Its pointer, not numbered in the L & N woodcut, can be seen attached to the bottom of the coil. When the circuit is balanced this pointer lies directly under the space between the ends of the two ⅂-shaped levers 4L and 4R. *Nothing happens*, except that shaft 6 keeps on turning. The cams which it carries, cannot do anything which will alter the relative position of the slide wire and its contact, nor which will move the pen (or print wheel) across the chart. The record will be a straight line, showing unchanged temperature—whatever the degree.

But how did the pen or print wheel get to its place? The answer is implied in the description of what happens when the temperature rises or falls, causing a temporary state of unbalance:

Shaft 6 revolves at a speed of about 30 r. p. m. Every two seconds or so, cam 6B raises rocker arm 5. In its "low" position this arm does not touch the pointer, but as it rises it picks up the pointer and lifts it a small fraction of an inch—always the same distance. In its mid-arc position the pointer rises between levers 4L and 4R; in any other position it causes one lever or the other of these levers to rotate. (They are pivoted at both points marked 24E.) With the pointer deflected to the left, 4L is rotated and its lower end moves 2C and swings the arm 2, connected to disk 1 by a clutch. Disk 1 does not move—yet: it is disengaged from 2 at this moment, by the action of cam 6C. But now, as shaft 6 continues to rotate, cam 6B allows rocker arm 5 to fall and then cam 6C allows 1 and 2 to be engaged. Whatever rotation is now imparted to 2 will equally rotate 1.

The next action is that of the large cams 6E, which straighten out 2 and in doing this rotate 1. The angular movement is proportional to the pointer deflection.

On the same shaft with 1 are the slide resistances R and DE, Fig. 29,* which are wound on the circumferences of the disks visible in Fig. 91. The relationships are such that when movements like the one described above take place the direction of rotation is such as will tend to restore a balance in the measuring circuit.

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*See page 231, April INSTRUMENTS.

The recording pen (or print wheel) is connected to the disc carrying the slide resistance, and moves with it, so keeping a record of its balance positions. The amount of rotation given to arm 2 and to disc 1 depends on the extent of the galvanometer deflection, since the pointer approaches the fulcrum of the lever as the deflection increases. Consequently the re-balancing movement will be large or small as the unbalance is large or small. It will be noted that the force of the deflection serves to put the pointer in position, and that absolutely no other work is required of the sensitive galvanometer. All the work is done by the motor, but the extent of the work and its direction are controlled by the galvanometer.

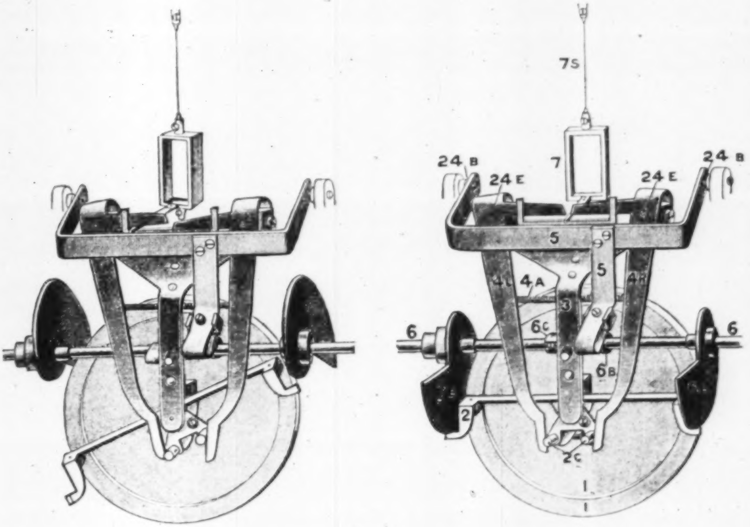

Fig. 90

The motion of 5 is adjusted so that the rotation of 2 will correspond to a rebalancing step of the pen of 3/4″ when the deflection is a maximum, and decreases uniformly to about 1/50″ when the deflection is just sufficient to catch the pointer under one of the right-angle levers. This gives sufficient rapidity of the various actions to take the pen the width of the scale in somewhat less than one minute. A record is made once a minute on the multiple-point recorders of standard design. Ths position of the pen or print wheel, when a balance has been obtained just before each record, corresponds to a definite point on the slide wire, for the pen or print wheel is fixed to a cord fast to the slide-wire disk and is wound or unwound with the rotation of the disk.

Once during a revolution of the commutator, the thermo-couple is disconnected and the standard-cell connection made. At the same time the potentiometer slide wire is let loose from its shaft and the clutch engages a second resistance *R*, Fig. 29, which is also wound on the circumference of a disk (visible in Fig. 91) at the back of 1. Movements of the disk then results in changing the resistance of the battery circuit, and the current is thus set to its proper value. The pen does not follow this adjustment, and no record is made of variations in the current. With batteries in fair condition, the current is easily maintained constant; but if there arises any doubt of this constancy, the recorder may be watched for a few minutes, and when the standard-cell connection is made the first deflection of the galvanometer is an indication of the change in the current since the last adjustment. A short-circuiting contact on the slide wire carries the pen to zero on the chart when the battery has run down, thus providing ample warning under most circumstances.

The scale of this recorder is uniform when graduated in millivolts, and departs from uniformity for a temperature graduation according to the temperature-emf relation of the thermocouple. The standard galvanometer is sufficiently sensitive to work satisfactorily with a full-scale range of 10 millivolts, which gives a very open scale, particularly for base-metal

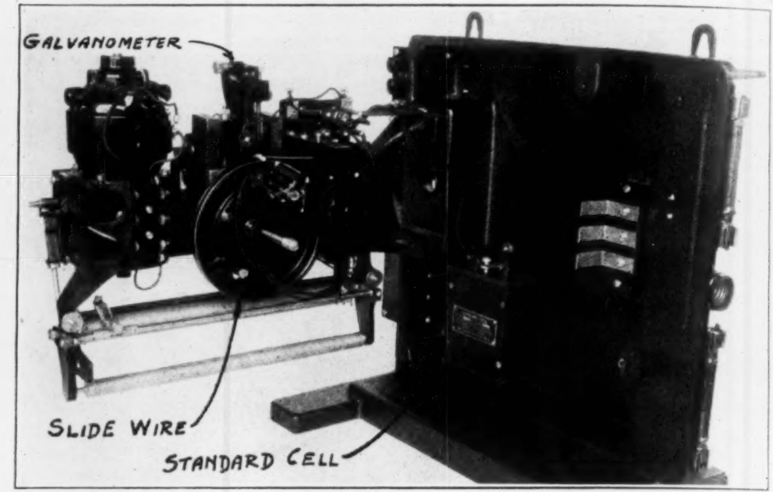

Fig. 91

couples, when 0.1″ of scale corresponds to 4.5°F. This recorder is used with resistance thermometers, in which case the electrical circuit takes the form of a Wheatstone bridge, as described in Part 2, and the scale can be opened until the entire range corresponds to as little as 3.6°F. The zero of the scale can be adjusted to correspond to any fixed emf, so that the scale may be put within any range of temperature desired. The adaptability of the instrument is readily apparent.*

(2) *Wilson-Maeulen.*

The most evident feature of this recorder is the wide chart—12″ with a scale 11″ long providing "the greatest width of record of any temperature recorder." ($2\frac{1}{3}$ times as long as that on the largest round recording thermometer chart.) Another obvious feature is the external location of the motor drive, allowing a group of recorders to be operated together by one drive unit. In the mechanism the principal feature is that the recording pen and slide wire contact brush are integral. The following is substantially extracted from the Company's literature and descriptions.**

The record is immediately in sight as soon as made, and hangs vertically in view immediately behind the glass window. The pen never lifts from the paper, and the record is, therefore, continuous without interruption.

This recorder can be supplied with a chart speed of ¾″ per hour, 1½″ per hour, or 3″ per hour.

Changes of temperature at the thermocouple cold junction are automatically compensated for in the instrument by the same electrical method employed in Wilson-Maeulen indicators, Tapalog recorders, and automatic temperature controllers.***

The sprocket at one end of the paper drum is adjustable as to distance from the other end and the drum can thus be accommodated to any great variation in the chart paper due to atmospheric conditions.

The check switch lever is located outside the case. Replacement of the galvanometer is easily done. The standard cell is easily disconnected and replaced. The pen may be filled without moving it from its holder.

All parts of the mechanism inside the case are slow speed. The entire mechanism is easily reached for either cleaning or oiling.

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*This description (in small type) is a composite affair: author's own for about one-half, then a little from the L. & N Direction Book and the last two paragraphs adapted from *Bureau of Standard's Technical Paper* 170.

**Including an article by Frank Moore in the *Review of Scientific Instruments* for March, 1930.

***See Fig. 26, p. 229, April INSTRUMENTS.

The method used to bring about relative movement of the slide wire and its contact, as a result of galvanometer deflection, is as follows: the galvanometer needle or (as it is called in the article), "arm" is periodically locked in it's steady position by clamping the arm between friction-faces. Two ratchet arms, carrying a roller ratchet on one end of each, are pivoted scissors-fashion on the internal hub of an annuallarly recessed drum about the axis of which they oscillate in opposite directions and in synchronism with the action of the galvanometer arm clamp. Two release arms, the lower ends of which are pivoted approximately coaxial with the ratchet arms, keep the rollers of the roller ratchets out of engagement with the inner surface of the drum rim as they move to and fro with the ratchet arms, the upper extremities projecting beyond the drum rim. When the galvanometer arm is clamped in the center or undeflected position, the release arm extremities move from the ends of the path of deflection of the galvanometer arm to the center, or undeflected position, *and return, in a plane at right angle to the plane of deflection, without causing drum rotation.*

When the galvanometer arm is clamped in a deflected position, it halts one or the other of the release arms, depending upon the direction of deflection, allowing the roller of the corresponding roller ratchet to engage with the drum and rotate it through the remainder of the angle of travel of the ratchet arm, the angle of rotation being greater the greater the angle of deflection of the galvanometer arm. During the return travel of the ratchet arm, at the beginning of which it is automatically released from the drum by inherent hatchet action, it picks up the release arm, thereby putting the roller again in a disengaged position preparatory to a repitional excursion of the ratchet arms.

A slide wire, located in proximity and transverse to the chart, has its movable contact attached to a carriage to which is also attached the pen. A belt, in effect endless, a portion of which is wrapped on the recessed drum, is guided by pulleys to move the carriage, with the attached slide-wire contact and pen, parallel to the slide wire, in direction and magnitude corresponding to that of drum rotation.

The action of the release arm extremities, analogous to exploring for and sensing the position of the clamped galvanometer coil arm, characterizes this type of self balancing instrument as an "exploring type."

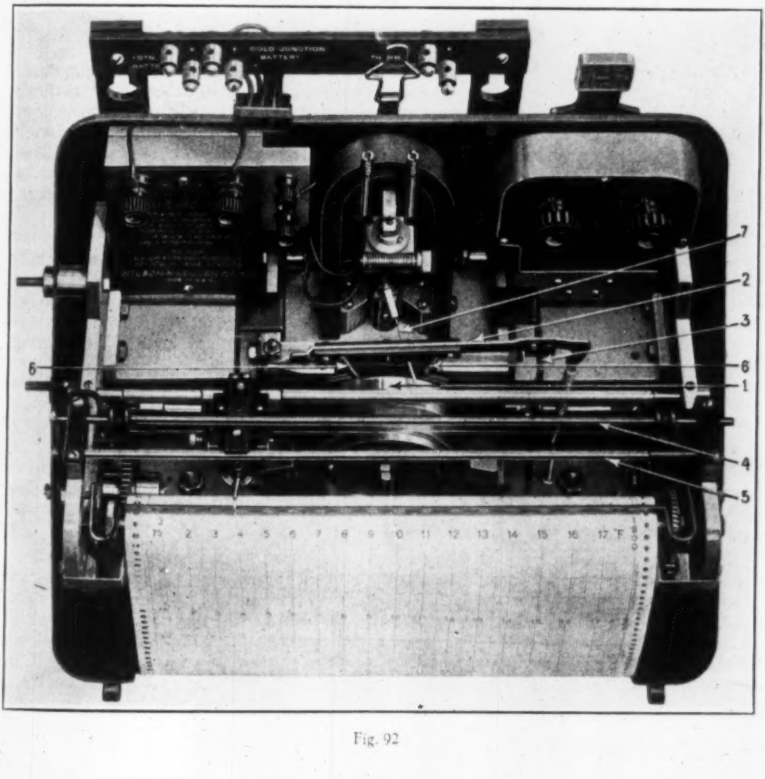


Fig. 92

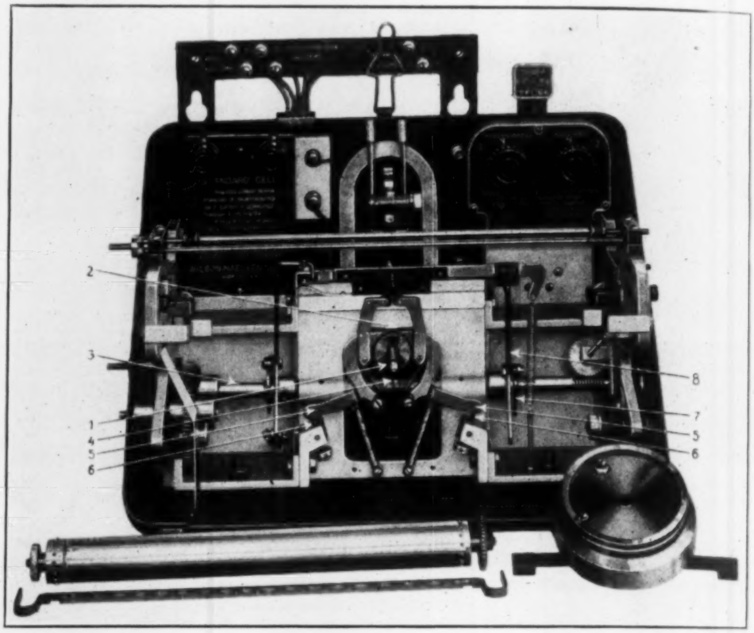


Fig. 93

Fig. 92 is a view from above showing the galvanometer, which is of the taut-suspension type, with its moving coil with attached arm 7 in a deflected position. The forward narrower portion of the arm, of pressed duralumin, rectangular in section, is attached to the coil by a broad thin spring tongue of phosphor bronze, so that vertical movement of the tip of the galvanometer arm is not imparted to the galvanometer coil. The clamp bar 2, shown in a raised position over the tip of the galvanometer arm, is built up of two plates of bakelite bolted to the sides of the metal portion, as shown in Fig. 92, the lower edges of the bakelite projecting below to form two parallel clamp surfaces. The extreme left end of the metal portion of the clamp bar forms the socket of a ball and socket swivel that acts as the hinge for the clamp bar. Near the right end, attached with two screws is a small hardened steel plate, with a knife edge that engages in a *V* slot in the cam operated lifter arm 3 which raises and lowers the end of the clamp bar. When the lifter arm moves downward the tension of the spring attached to the downward-bent extreme right end of the clamp bar keeps it from rotating endwise until clamping actually occurs, when the clamp bar, acting under the tension of the spring, is free to seat both of the clamp surfaces firmly on to the galvanometer coil arm. The other member of the clamp, the stationary block beneath the pointer, is grooved longitudinally so that it presents to the galvanometer arm two clamping faces which are at all times directly below those of the clamp bar. Parallelism of the surfaces clamping the galvanometer arm is assured by the adjustable ball and socket swivel. Thus by clamping the galvanometer arm at two separated places along its length between two pairs of parallel surfaces, the efficiency of clamping is greatly increased over that of a single pair of clamping surfaces. It is worthy of note that the clamping faces are smooth and unbroken from one extent of the galvanometer arm deflection to the other.

Previously mentioned (under "the method used") are two release arms associated with a roller ratchet mechanism. The extremities of the release arms, projecting beyond the ratchet drum, are shown at 6 and 6 Fig. 92. These extremities of bakelite, and the metal release arms to which they are rigidly attached, will, hereafter, be termed "sensing fingers." In the position shown, the sensing fingers are at the extreme outward travel; that is, they are moved their maximum distance away from the undeflected or center position of the galvanometer arm. In Fig. 92, the galvanometer arm is shown deflected from its center position, but unclamped. When it is clamped in the same deflected position, and the sensing fingers have moved inwardly, the one on the left will have uninterruptedly completed its inward travel, keeping its roller ratchet inactive. The sensing finger on the right will have been halted by the clamped deflected galvanometer arm on its inward travel, and, as the roller ratchet moves inwardly and away from the now stationary sensing finger (or release arm) it immediately engages with the inner surface of the drum 1, rotating it counter-clockwise. The drum, during rotation, winds the catgut belt (which shows as a white line parallel to and below slide wire 4) on from one side and off from the other (in this case: on from the right and off from the left) pulling the pen carriage transversely to the chart.

The slide wire is shown at 4 and a contact rod at 5. The pen carriage carries the flat spring for the slide wire contact, which is shown just below the slide wire, and also a rigid contact arm which rests on the contact rod, supporting the weight of the pen carriage at the front. The slide wire contact and the rigid contact arm are electrically connected to each other but insulated from the pen carriage by the bakelite block upon which they are mounted. The pressure of the slide wire contact on the slide wire is adjusted by means of a screw. Using the contact rod as a front support for the pen carriage and at the same time as a return circuit from the slide wire brush eliminates the use of flexible leads attached to the movable carriage and relieves the slide wire itself of undue pressure at the point of contact.

Fig. 93 is a front view of the partially dismantled recorder. The chart drum and chart scale are in the left foreground and the ratchet assembly, as removed from the ratchet drum spindle 1, is shown at the right. The galvanometer arm, shown clamped in its central or undeflected position, is in contact with both sensing fingers. The attached lower portions of the sensing fingers (previously spoken of as release arms) are shown pivoted at their lower extremities. The tension of a light bronze spring 2 tends to draw the sensing fingers together, and thus provide the necessary pressure, when the whole is assembled, to keep the roller ratchets out of engagement.

The main shaft 3 Fig. 93 extends through the frame assembly from one side to the other, carrying the bakelite expanding or double skew cam 4 between two pressed-in bronze bearings (indicated by the oil holes). The main shaft is driven from a motor and gear reduction assembly which mounts on the recorder frame proper, being independent of the steel case, Fig. 92.

The rotation of the expanding cam rotates the driving arms about the drum spindle 1 Fig. 93 raising the extensions 5, 5 against, and lowering them with, the tension of the two driving springs, the downward travel being limited by the two stop screws 6, 6. When assembled the extensions 5, 5 of the driving arms engage with the bentover ends of the ratchet arms, seen projecting on either side from under the ratchet drum (lower right of picture) thus imparting the oscillatory motion to the ratchet arms as previously described. The rotation of the main shaft also raises and lowers the right hand end of the clamp bar through the medium of the clamp bar cam 7 and the lifter arm 8.

(3) *Uehling.*

At the time of writing, the author has not yet had an opportunity of examining this instrument (or group or system as will appear in the description). A striking feature of the round-chart recorder is an illuminated indicating scale *twenty-four* inches long. The novel "action" is explained in the following description contributed by the maker:

". . . The Uehling Self Contact Potentiometer Pyrometer utilizes a novel method which assures a definite and reliable contact with the needle of the galvanometer when deflected in one direction or the other, without the necessity of a continuously operating motor, cams or depressor bars. Although all of the advantages of the potentiometer are retained, the novel contact method makes it possible to place the galvanometer apart, and at almost any distance from the recorder. This makes possible a very simple and rugged recorder construction. One galvanometer will actuate as many as six recorders, each in a different location, each measuring a different temperature, and if desired, each having a different calibration."

Fig. 94 illustrates the recorder while Fig. 95 illustrates the relay box which contains the galvanometer that actuates the recorder. The recording mechanism consists only of a motor M, figure 96, which rotates a cylinder 1 on which slide wire 2 is helically wound. A grooved wheel 3 is held tightly against wire 2 and is fastened to a support which slides on a horizontal rod 4. Due to the pitch of the wire on cylinder 1, the wheel with its support moves from left to right and from right to left, depending upon the direction in which motor M is operating. A marking pen 6 is fastened to the sliding support which carries wheel 3, and rests against a clock-driven chart 7 so that a record of any variation in the position of the wheel will be recorded.

The galvanometer G, Fig. 96, is located in the relay box, Fig. 95. The pivoted coil 11 of the galvanometer forms part of a circuit which includes a thermo-couple C, a resistance R and that part of the potentiometer wire between wheel 3 and connection 15. A constant current flows through wire 2 from a battery 8 so that by actuating the motor M in one direction or the other to change the position of wheel 3, the drop in potential across the wire between wheel 3 and connection 15 may be adjusted to balance the emf of the couple C. The motor may be operated in one direction or the other depending upon which of two mercury switches 27 and 28 is closed. Switch 27 is fastened to a tiltable frame X so that when the frame is tilted by an electro-magnet $M2$ the circuit through the switch will be closed and when the frame is in its untilted position the circuit through it will be open. The mercury switch 28 for operating the motor in the opposite direction is similarly fastened to a tiltable frame Y actuated by an electro-magnet $M1$.

On the same tiltable frame with switch 27 is also fastened a mercury switch 21. This switch is included in the circuit with magnet $M2$ and is so fastened to frame X that when the frame is tilted by magnet $M2$, the circuit which includes the switch and the magnet will be open and when in its untilted position, the circuit will be closed. Similarly, on the same tiltable frame with the switch 28, is fastened a mercury switch 25. This switch is included in the circuit with magnet $M1$ and is so fastened to frame Y that when the frame is tilted by magnet $M1$, the circuit which includes the switch and the magnet will be open and when in its untilted position, the circuit will be closed.

The circuit which includes switch 21 and magnet $M2$ also includes resistance R; the needle 17 of the galvanometer, a contact piece 18 and a battery 20, while the circuit which includes switch 25 and magnet $M1$ again includes resistance R and needle 17, and also a contact piece 19 and a battery 24. It will be noted that resistance R is included in three circuits; 1st the circuit which includes needle 17 and contact piece 18, 2nd the circuit which includes the needle and the contact piece 19, and 3rd the circuit which includes the coil 11, the couple C and the potentiometer. It is this fact which eliminates the necessity of auxiliary mechanical forces to insure electric contact between the needle 17 and either of the contact pieces 18 and 19.

To illustrate the part which resistance R plays, let us assume that the emf of couple C is just slightly in excess of the drop across wire 2 between wheel 3 and connection 15. This will deflect the needle to the right and cause a delicate contact between the needle and contact piece 19. Due to the high electrical resistance which always accompanies a delicate contact, the "current" which flows between the needle and the contact piece is insufficient to actuate magnet $M1$. Regardless of its minuteness, however, this current causes some drop in potential across resistance R. This drop causes an electric flow through coil 11, couple C and the potentiometer. The polarity of battery 24 is such that the flow through coil 11 as caused by the drop across R is in the proper direction to force the needle tighter against the contact piece 19, decreasing the contact resistance and increasing the flow through magnet $M1$ and resistance R. This increased flow further increases the drop across resistance R, which increased drop further increases the flow through coil 11 with a resulting further increase of tension between the needle and the conact piece. This increased tension between the

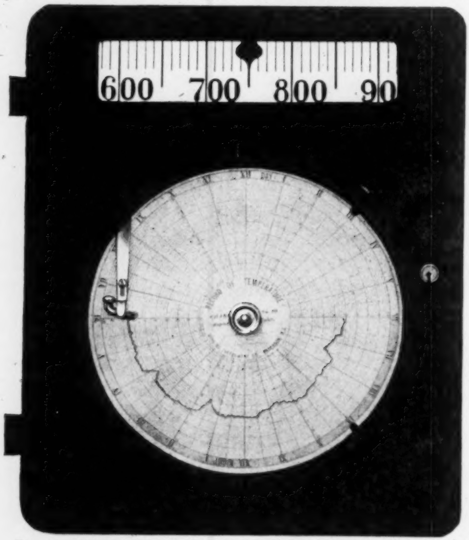


Fig. 94. Uehling round chart recording potentiometer. Other model has 8" strip-chart, one hundred days per roll. (*Uehling Instrument Company.*)

needle and contact piece 19 still further increases the flow through magnet M1 and resistance R with a resulting still greater tension between the needle and the contact piece.

In other words, as soon as there is the slightest contact between needle 17 and contact piece 19, the pressure which the needle exerts against the contact piece will continue to increase until there is sufficient current flowing through magnet M1 to tilt frame Y. The tilting of the frame breaks the circuit in switch 25 thus de-energizing magnet M1 and permitting frame Y to return to its normal position thus again closing switch 25. If needle 17 still touches contact piece 19, no matter how slightly, this action will repeat itself. So long as needle 17 touches contact 19, so long will frame Y with its mercury switches 25 and 28 continue to rock, thereby actuating motor M in the proper direction to shift wheel 3 to the right until the drop in potential between the wheel and connection 15 has been increased sufficiently to balance the increased electro-motive force of the couple. The needle will then be in its normal position as illustrated. The frame Y will cease to rock and the motor will stop.

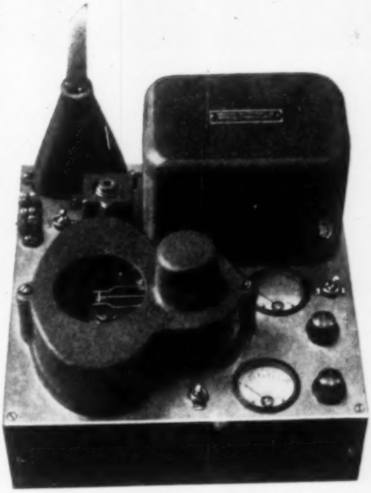


Fig. 95 (Above)

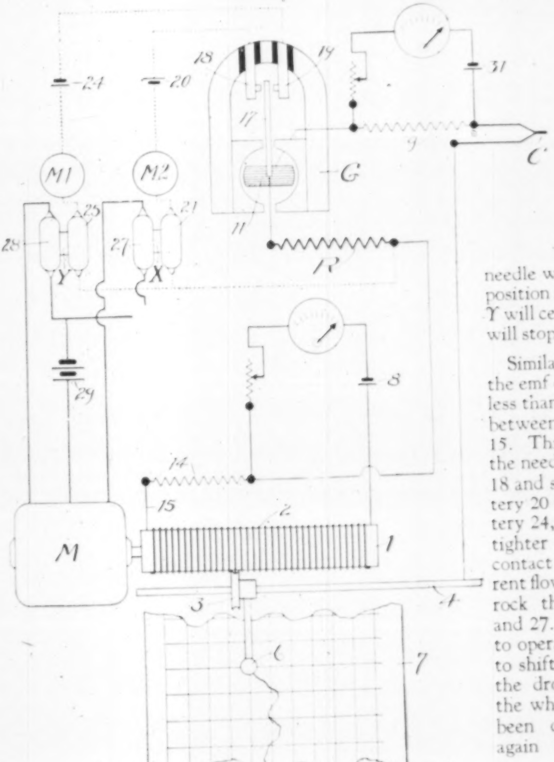


Fig. 96 (Left)

Similarly, let us assume that the emf of the couple is slightly less than the drop across wire 2 between wheel 3 and connection 15. This condition will deflect the needle against contact piece 18 and since the polarity of battery 20 is opposite to that of battery 24, the needle will be forced tighter and tighter against the contact piece until sufficient current flows through magnet M2 to rock the mercury switches 21 and 27. This will cause the motor to operate in the proper direction to shift wheel 3 to the left until the drop in potential between the wheel and connection 15 has been decreased sufficiently to again balance the emf of the couple. The needle will then again assume its normal position as illustrated, the mercury switches 21 and 27 will no longer rock, and motor *M* will stop. Pen 6 thus moves in one direction or the other in proportion to changes in the couple emf, while chart 7 over which the pen travels is calibrated in corresponding temperature units.

Variations in the temperature of the cold end of the thermocouple are compensated for by a resistance 9 composed of a material with a high temperature coefficient. The current flowing through the resistance is supplied by a battery 31 of the proper polarity to effect a balance for any change in cold end temperature, the cold end being located in proximity of the resistance. The drop across the resistance at a predetermined normal temperature for the cold end is balanced by the drop across a constant resistance 14. The current which flows through potentiometer wire 2 and resistance 14 is so small (only a few milli-amperes) that an ordinary dry cell will provide the necessary continuous and constant flow for a period of two years or more with little or no adjustment. The same applies to battery 31 which supplies the current through the resistance 9.

Equipment embodying the Self Contact Method is manufactured by the Uehling Instrument Company under F. F. Uehling patents.

The Next Development

Each of these three recording potentiometers seems to come pretty close to electrical and mechanical perfection but the author, somewhat acquainted with what is being done in designing certain instruments not related to temperature, cannot resist the impulse to set up as prophet and to predict that a further development is coming. The development may or may not be an improvement—except in one important respect: There will be no contact with the galvanometer needle which will always swing freely without touching anything . . . and without being subjected to magnetic drag or other distance force. The discussions regarding "proportional" and "step" methods of restoring balance (and of effecting automatic control, as will be discussed in Part 5) will probably have no more ground to feed on. The answer? LIGHT! The shadow of the needle, or a reflected beam as in present laboratory galvanometers, will actuate the self-balancing mechanism, and with it the recording device or automatic control relay.

Care and Maintenance of Recorders

The author has received direction cards and books from the majority of manufacturers, and has read them all, comparing one another. So thoroughly are all important points mentioned that nothing is needed in such a Handbook as this.

Utilizing Expansion of Equipment

The temperature of rotary retorts, 10 ft. diameter and 75 ft. long, at the New Brunswick low-temperature carbonization plant of the International Carbonization Co. is recorded on instruments developed by the Shallcross Control Systems Co., which utilize the huge shells as expansion thermometers. In order to correct for atmospheric temperature, each recorder is actuated by the differential expansion of the inner and outer shells. This novel principle—making the equipment its own thermometer—deserves consideration with regard to other applications.

Signalling Devices

Indicating and recording temperature instruments can be provided with contact points whereby signal lights are flashed or electric bells rung at predetermined degrees. If, instead of these signals, electric relays are introduced to operate valves, etc., the instruments are in reality automatic controllers and belong in the next and final part of this Chapter.

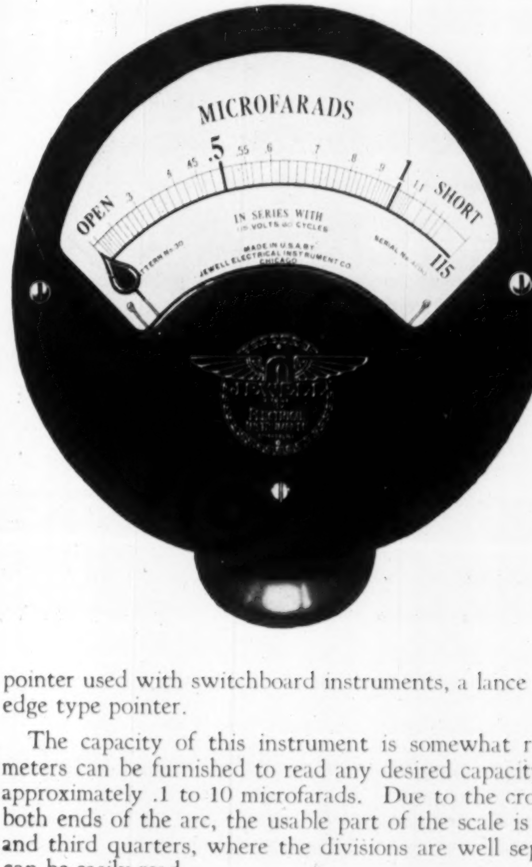
NEW INSTRUMENTS

Recently Developed by Instrument Manufacturers

Write Information Section, Instruments Publishing Co., Pittsburgh, Pa., for additional information.

Pattern 30 Microfarad Meter

THE Jewell Electrical Instrument Company has developed a Microfarad Meter which is available in a number of forms. The instrument consists of the well known Jewell Pattern 30 A. C. Switchboard Instrument, with a scale that reads direct in microfarads. This Pattern 30 has a 7″ circular steel case with a very large scale opening, and a scale length of 5″.



The instrument is available in two forms: one is the regular front-of-board type switch board instrument with standard switchboard lugs at the rear of the meter; the other method of mounting uses the same style of case, but the case is mounted on a pedestal at an angle of approximately 45 degrees. Binding posts are supplied at the rear in place of standard switch board studs.

This instrument is furnished with 3 types of pointers: the standard large size spade pointer used with switchboard instruments, a lance tip pointer, or a knife edge type pointer.

The capacity of this instrument is somewhat restricted. Individual meters can be furnished to read any desired capacity at center scale from approximately .1 to 10 microfarads. Due to the crowding of the scale at both ends of the arc, the usable part of the scale is limited to the second and third quarters, where the divisions are well separated, and the scale can be easily read.

Meters to measure more than one capacity can be furnished over such ranges as:

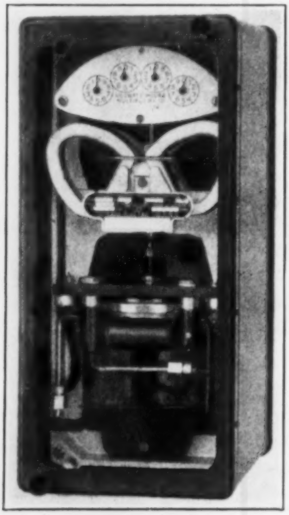
.1 - .3 Microfarads
.25- .5 Microfarads
.5 -1.0 Microfarads
1 -3 Microfarads
2 -5 Microfarads
4 -8 Microfarads

This method of measuring capacity depends on the frequency and voltage of the test circuit. The frequency of light and power circuits is now held within such narrow limits that errors due to frequency are entirely negligible. The voltage of the test circuit must be held at some predetermined value. Errors in capacity indication due to voltage will be directly proportional to the variations in the voltage of the test.

Since these instruments are frequently furnished for inspection work when large quantities of condensers of the same capacity are to be tested, they are furnished wirh scales particularly fitted for quantity production work. For example: one type of scale is furnished to check but one capacity, another type is furnished for checking 2 values, and still another type is available for general use. The general purpose scale is not so practical for rapid inspection testing, since the presence of so many divisions on this scale make it most difficult to read.

Changes Made in General Electric Watthour Meter

SEVERAL changes in its mercury-type direct-current watt-hour meter (Type HS-11) have been announced by the General Electric Company. Provision has been made for periodic renewal of the mercury. The cup, now made of metal, is built as one unit complete with rotor and mercury and is easily replaceable; this removes the necessity for dissembling and cleaning the mercury chamber. The voltage characteristic of the meter has also been improved. For uniformity of appearance the meters are furnished in the rectangular case used for other General Electric switchboard devices.

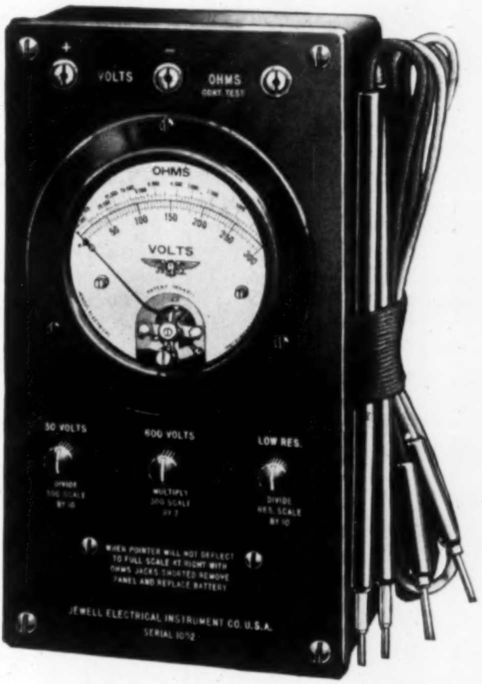


The shunted meter is particularly well adapted where first cost, panel space or bus limitations are of major importance. Its principal advantages arise from the fact that it can be operated from a shunt, and the heavy bus structure need not be carried directly to the meter.

Pattern 574 Service Voltohmmeter

(Jewell Electrical Instrument Corp.)

THE Pattern No. 574 Service Voltohmmeter has been designed especially for the service man or tester who depends on voltage, resistance, or continuity readings in making his tests.


VOLTS
OHMS
CONT. TEST
OHMS
VOLTS
30 VOLTS
DIVIDE 300 SCALE BY 10
600 VOLTS
MULTIPLY 300 SCALE BY 2
LOW RES.
DIVIDE RES. SCALE BY 10
WHEN POINTER WILL NOT DEFLECT TO FULL SCALE AT RIGHT WITH OHMS JACKS SHORTED REMOVE PANEL AND REPLACE BATTERY
JEWELL ELECTRICAL INSTRUMENT CO. U.S.A.
SERIAL 1002

The instrument consists of a three and one-half inch face, Bakelite case meter mounted on a panel, together with three jacks for terminals and three push buttons for controlling the ranges of the meter. A 4.5 volt battery is mounted below the panel for use in making resistance and continuity measurements. The panel is mounted in a case giving the instrument overall dimensions of $2\frac{1}{2}$x4x$7\frac{1}{8}$ inches. An elastic band around the case provides very satisfactory means for holding test leads furnished with the instrument when not in use.

The case is supplied with smooth surfaces and rounded corners, so as to avoid the scratching or marring of any surface onto which the instrument may be placed.

The meter has two scales; the upper scale reads in ohms directly from 0 to 100,000. This range can be decreased to one-tenth of this value by using the right hand "LOW RES," button. When this button is pressed, the value of the resistance being measured is one-tenth of that indicated on the scale.

The lower scale reads in voltage directly from 0 to 300. This range can be decreased to 0 to 30 volts by using the "30 VOLTS" button and dividing the readings obtained by ten, or it can be increased to 0 to 600 volts by using the "600 VOLTS" button and multiplying the readings obtained by two.

The push buttons are of the locking type, that is, they may be locked down by pressing the button and rotating it slightly. The white bar on the surface of the button indicates whether the button is in the "up" or the "pressed" position. The white bars will be vertical when the buttons are "up."

To use the instrument as a voltmeter, place either end of either test lead supplied in the "VOLTS" jacks and use the free ends of the leads to connect to the circuit under test. The reading obtained is on the 300 volt scale. If below 30 volts or more than 300 volts, press the "30 VOLTS" or the "600 VOLTS" button to change the range for more accurate readings.

For convenience in testing, the red lead should be connected to the jack marked "+". With this connection of the test leads the points touched with the red lead are positive with reference to points touched with the black lead when the meter reads forward. The reverse is true when the meter reads backwards.

When used as a voltmeter, the meter has a resistance of 1000 ohms per volt on each of its ranges.

To use the instrument as an ohmmeter, place either end of each test lead in the "OHMS" jacks and use the free ends of the leads to connect to the circuit under test. The reading obtained is on the ohms scale. If below 2000 ohms, press the "LOW RES." button and divide the reading obtained by ten.

To use the instrument as a continuity tester, connect the leads as for the ohmmeter. With this connection, the 4.5 volt battery, which is inside the instrument, is connected in series with the meter and the "OHMS" jacks. The meter reads 4.5 volts full scale. A short circuit or a very low resistance circuit should give approximately full scale deflection, while circuits which are continuous but of higher resistance will give correspondingly smaller deflections. When the "LOW RES." button is "up," the current for full scale deflection is 1 milliampere and the resistance of the circuit being tested for continuity is indicated in ohms on the ohms scale. When the "LOW RES." button is pressed, the current for full scale deflection is 10 milliamperes and the resistance of the circuit being tested for continuity is indicated in ohms by dividing the reading on the ohms scale by ten.

The Pattern No. 574 is supplied complete with test leads and battery. The test leads are so arranged that either end of the lead may be inserted in the jacks on the instrument. This allows either the long tip or the short tip to be used, depending on which is most convenient in connecting to the circuit under test. The battery should be replaced when shorting the "OHMS" jacks does not produce full scale deflection to the right by two divisions or more. The voltage of a new 4.5 volt battery is generally over 4.5 volts. Hence, with such a battery in the instrument, something over full scale deflection to the right will be obtained when the "OHMS" jacks are shorted.

* * *

Connelly Iron Sponge & Governor Co., Chicago, Ill., has taken over the manufacture and sale of the Lamphier Caloroptic, a B.t.u. indicator, formerly made and sold by Rossiter & Co., Inc., New York, N. Y.

* * *

The Brown Instrument Company, Philadelphia, Pa., announces the consolidation of its Chicago Sales Office and Midwestern Factory Branch in new quarters located at 155 East Superior Street, Chicago, Illinois. Practically double the former space has been provided in line with the growth of business throughout the Middle West, and a large stock of replacement material is carried on hand ready for prompt shipment.

A. P. C. Opacimeter

(American Photoelectric Corp.)

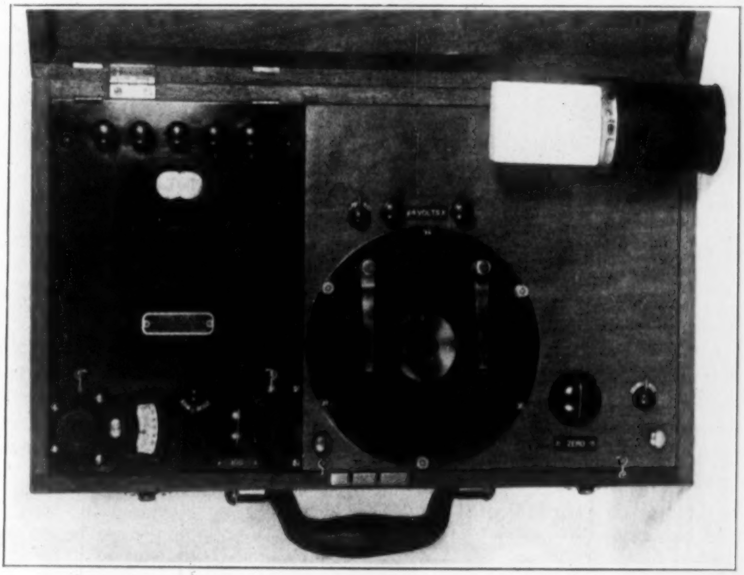
THE operation of this instrument is based on the same principles as those embodied in the A. P. C. photoelectric spectrophotometer*, but as its application is limited its operation is very simple.

The construction of the instrument and its method of operation are such that determinations of opacity are independent of the color and surface reflection characteristics of the material being tested.

All readings are made electrically so that errors inherent to visual observation are wholly eliminated, and the instrument is operated in daylight or under artificial illumination, which increases the facility and speed with which determinations can be made.

The instrument is unique in that readings are independent of

a. The voltage to the illuminating lamps.
b. The spectral distribution of the color emitted by the illuminating lamps.
c. The color sensitivity curve of the photoelectric tube.
d. The grid-voltage plate-current characteristics of the amplifying tubes.



The instrument is accurate to within 0.5%, and anyone experienced in its use can easily secure check readings within 0.2%. When it is considered that even a high quality of paper may vary more than 3% in opacity through a given width in the roll, it is readily seen that this instrument may be useful in the control of the manufacturing process.

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*Instruments, Feb. 1930, pages 145-147.

In order to secure results that will be directly comparable over long periods, only one precaution is necessary, and that is to insure that all samples tested either are quite dry, or else that they have been stored under identical conditions of temperature and humidity. The research on papers that resulted in the development of this instrument proved conclusively that their opacity factors varied with fluctuations of the absolute humidity of the atmosphere in which they had been stored.

In addition to measuring the opacities of papers directly in percent on a scale where the difference between black and a block of magnesium carbonate illuminated through the sample equals 100%, it also is possible to evaluate combinations of different papers and inks merely by the substitution of the paper itself for the magnesium carbonate block. This will be easily understood from the following description of the method of operation based on the photograph.

The sample is slipped under the two clips on top of the round metal disc so that the circular orifice therein is completely covered. A reflector coated with magnesium oxide is under the round metal disc, and illuminating lamps not visible in the photograph, are equally spaced within the reflector. A photoelectric cell is located under the small tube that projects through the reflector towards the circular orifice in the round metal disc.

A 6-volt battery is connected to the two terminals at the right of the round metal disc. This supplies the energy required by the illuminating lamps within the reflector through the switch above the terminals.

The two switches adjacent to the potentiometer knobs marked ZERO and 100 are set at their ON positions. This completes the circuits to the amplifying tubes and connects the biasing batteries into their circuits.

The lock on the galvanometer in the upper left-hand corner is released so that the indicating needle can move, and the dial of the Kohlrausch slide wire bridge in the upper right-hand corner is set at zero by turning the knob located between the dial and the nameplate.

The sample is covered with the black lined box shown in the upper right-hand corner, the illuminating lamps are turned off by the switch adjacent to the two terminals, and the galvanometer needle is brought to rest at its zero by turning potentiometer knob marked ZERO. This establishes the 0% point of the scale on which the capacity is measured.

The black lined box is then replaced by the magnesium carbonate block seen in the upper right-hand corner, the illuminating lamps within reflector are turned on by the switch adjacent to the two terminals, the dial of the Kohlrausch bridge is set at 100, and the galvanometer needle brought to rest at its zero by turning potentiometer knob marked 100. This establishes the 100% point of the scale on which the capacity is measured.

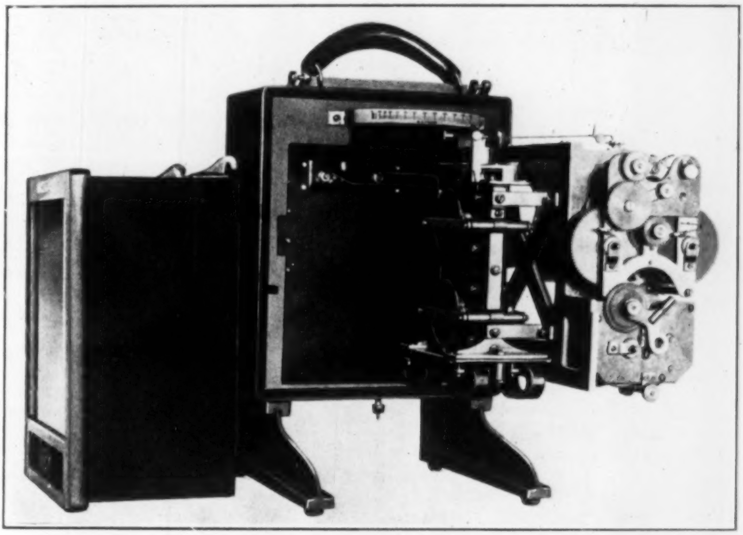
Now, with sample still illuminated, the magnesium carbonate block is replaced by the black lined box, whereupon the galvanometer needle, unless the sample is 100% opaque, will be deflected to its minus side. The galvanometer is then brought back to its zero by turning the knob on the Kohlrausch bridge, and the opacity of the sample is read directly in percent. on the bridge dial.

Less than a minute is required to make an opacity determination.

Graphic Instruments

(Roller-Smith Company)

ROLLER-SMITH graphic instruments are built into a light but very rigid metal base, the cover of which may be instantly removed, making the insertion of new rolls, the filling of ink well and other adjustments very convenient. To facilitate still further the making of adjustments which must be made when the instrument is in service the clock and chart mechanisms and the electrical mechanism, as well, are mounted on a common sub-base which is hinged on one side of the main base. This sub-base can be unlatched and swung outwards as shown. With the cover removed and the sub-plate swung open the operator can inspect every portion of the electrical and mechanical mechanisms with the greater facility and without the necessity of getting close to adjacent apparatus, a highly important point to consider in switchboard installations. Alternating and direct current instruments are alike as regards case, base and clock mechanisms, the sub-base being drilled differently to accommodate the various A. C. and D. C. movements.



The D. C. ammeter and voltmeter mechanism is an exceptionally sturdy high torque d'Arsonval type of construction. The moving element bearings are extra large size Ceylon sapphire jewels. The A. C. movements are of the dynamometer type of mechanism in which the field windings are mounted on a bakelite form. Highly efficient damping is secured by means of an aluminum disc passing between poles of powerful magnets, the principle used successfully for many years in watthour meters. Direct current ammeters are furnished with external shunts. All A. C. ammeters and wattmeters are of 5 amperes capacity and are designed for operation with standard current transformers.

The pen of the Roller-Smith graphic instrument can be removed from the instrument in two or three seconds time without the aid of tools and without the need of any extraordinary care. The inkwell, likewise, can be removed from its support by a single turn of a lever. It is not necessary, however, to remove the inkwell in order to refill it as a small lid on the top may be pushed aside and the well filled without disturbing the setting of the pen or any other part of the mechanism.

All graphic instruments are furnished regularly with gears for 5 speeds, namely, 3/4," 1 1/2," 3," 6" and 12" per hour. They have the strip of chart 5" wide with 4 1/2" scale. Chart is 75 ft. long. Average net weight is 30 lbs., average shipping weight 100 lbs.

Self-Contained Ohmmeter for Radio Servicemen

(Jewell Electrical Instrument Corp.)

THE Pattern 89 Ohmmeter, designed especially for radio service work, consists of a high grade direct current instrument mounted on a base of molded Bakelite, which carries a 1 1/2 volt flashlight cell. The Pattern 89 is therefore independent of external voltage supply.

Adjustment to correct for variation in the cell voltage is provided by a magnetic shunt, operated through a screw from the outside of the case. To provide accurate results the binding posts are short circuited before tests are made, and the pointer adjusted to the top of the scale at the zero point by manipulation of the screw. This places the instrument in correct working order, and resistance placed across the binding posts is accurately indicated on the scale.

OHMMETER
JEWELL ELECTRICAL INSTRUMENT CO.
CHICAGO, ILL.
OHMS
200
100
50
30
20
10
0

Since the adjustment to compensate for voltage variation may be made each time a series of readings are taken, the Pattern 89 is usually more accurate than a voltmeter and ammeter for similar work.

Current drawn from the standard flashlight cell is exceedingly low, being less than 30 milliamperes where the instrument reads to 1,000 ohms, and considerably less in high resistance instruments. With ordinary use the battery will last several months, and may readily be replaced by removing the 4 screws from the base of the instrument.

For radio service work, this instrument is particularly desirable because of its very rugged construction. It cannot be burned out if no external voltage is applied; it can only be damaged by extreme abuse. When used in conjunction with data supplied by set manufacturers, this instrument will be found ideal for continuity and resistance tests.

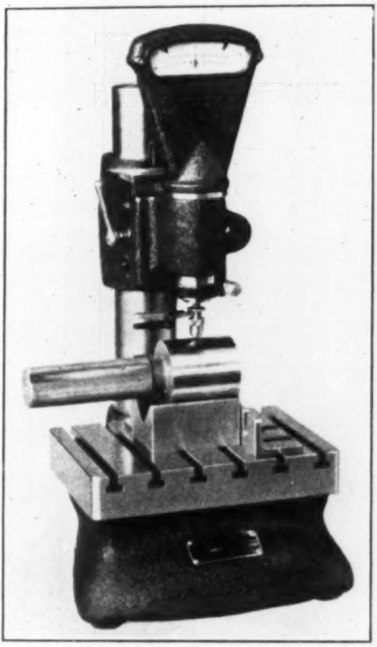
In railway signal service many measurements on apparatus such as selection of correct relay coils and ballast resistors, may be made with a Pattern 89.

New Société Genevoise Micro-Indicator Support

(R. Y. Ferner Company)

THE new micro-indicator stand is built to meet the high requirements of the accuracy which is possible with the micro-indicators which read to 1/10000″ per division and are guaranteed to 1% of their range of 0.006.″

The base and column of the stand are of very heavy construction. The column supporting the micro-indicator is 2″ in diameter and the total weight of the stand exclusive of the micro-indicator and the various accessories is 48 lbs.



The table for supporting the pieces being tested is 5 by 7″ in area and is made flat throughout within less than 0.0001″. This table is provided with six T slots which serve for securing in any position on the table 2 angle plates which may be so placed as to limit the position of the pieces being measured or of a V block 2½″ x 1 11/16 x 1⅜″ for the support of cylindrical pieces, as shown in the illustration. One face of one of the angle plates is 2¾ x 2⅜″ and the other is 1″ x 2¾.″ The other has faces 1″ x 2¾″ and 1⅜″ x 2¾″. Both faces are slotted for the bolts by which they are secured on the table, so they may be placed in either position, whichever happens to be best for the pieces to be inspected. Or, by means of the T slots, any special fixtures for supporting the pieces during inspection may be attached to the table.

The micro-indicator is supported in a heavy arm secured to the column by a strong clamp which permits turning the arm through any angle over the plate, according to the best position in which to place the work pieces. The axis of the micro-indicator is 3⅜″ from the face of the column.

Since the swinging of this arm would be prevented by use of a rack and pinion for vertical adjustment of the micro-indicator to a zero position over the standard gage at the beginning of the inspection, a fine adjustment is provided on the arm itself, for raising and lowering the piece holding the micro-indicator. This is operated by a large composition head on the end of the adjustment screw. The fine thread of the screw serves to make the zero setting of the indicator an easy and accurate adjustment. When this setting has been made a clamp can be applied to the slide to prevent any further movement.

To accomodate pieces of extra large area or having a shoulder or other projection which would otherwise interfere with suitably placing the piece on the table, an adjustment of the table forwards from its central position is provided, by which the table may be set forward 3/4". This would make it possible to balance flat pieces as large as 12" in width or diameter on the table for measurement. The vertical capacity of the apparatus is 6" when using the spherical contact point on the micro-Indicator. As the holder of the spherical contact point slips over the end of the contact plunger of the micro-indicator and this contact plunger has a hardened flat contact point at its end, the capacity can be increased to 6½" when the spherical contact point is removed.

With the help of the 2 angle plates and the Vee block, without use of special fixtures, the apparatus may be used for checking the 3 dimensions of flat blocks, the diameter of cylindrical pieces, the outer diameters and thickness of rings and ball or roller races, the diameters of steel balls, the major diameter of screws, the thickness of thin sheets or ribbons of material, or the diameter of wires and rods.

An added use of the stand may be had by the use of an adapter in the supporting arm to hold a micrometer microscope instead of the micro-indicator. The fine vertical adjustment of the holder will, in this case, serve for focusing the microscope on the object to be examined or measured, while the larger adjustment of the arm up and down on the vertical column will serve to adjust the microscope over pieces of several inches thickness, the limit depending on the working distance of the microscope objective used.

* * *

Datagraph

(Frank P. Fahy)

A test data form and graph sheet in one, designed for research and general test use and the compilation of reports.

This new test sheet is printed on high-grade 8½" x 11" unwatermarked Bond and blueprints excellently, thus inexpensively solving the exact copy problem. Margins are provided at the left and top to suit different binding and filing methods.

Datagraph was developed to fill a need long felt: an arrangement of test results and corresponding graph or graphs on the one sheet, thus giving compactness and solving the filing problem. Its design and the selection of the legends printed thereon are such that the one form will cover an extremely wide range of test use.

The data spaces, not including headings and sub-headings, number 128. By the use of the guide marks indented on the form this number of spaces can be expanded to 288. The graph section measures 10 x 17 cm., graduated in centimeters and millimeters.

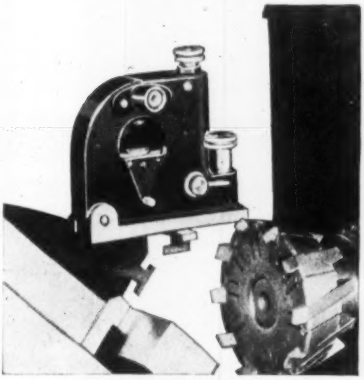
Datagraph is supplied in black (grayish-dark) and dark green printing. A space is provided at the top center of the sheet for such imprinting as may be desired.

Optical Bevel Protractor

(Bausch & Lomb Optical Company)

THE optical bevel protractor is used for turning out the most precise work—where the usual protractor would not be sufficiently accurate. Yet it can be used wherever the usual protractor is used.

It has an accurately machined base on which the main body is hinged. The body can be swivelled by turning a thumb screw. The level vial may be accurately positioned around the circular hole in the center of the instrument. As the head is turned, on the top of the instrument the worm drives a graduated dial within the instrument. A lever holds the worm in mesh with the graduated dial and by loosening it, the dial and vial can be quickly shifted for gross settings.



The dial itself is graduated to one sixth of a degree and every degree line is designated by a number. The graduations are observed through the eyepiece, which so magnifies the spaces between the graduations that a vernier can be read with ease to within one minute of arc.

To determine the relation of an inclined surface to a level surface the head of the worm shaft is turned until the dial vernier reads zero when observed through the eyepiece. Then the instrument is placed on the level surface. The thumb screw is turned inclining the body of the instrument relative to the base until the air bubble is central. This adjusts the instrument to compensate for any deviation from a true level of the surface on which the instrument has been set.

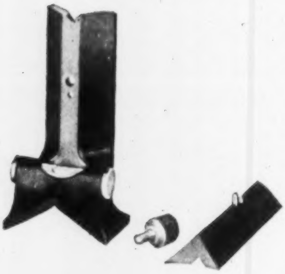
The protractor is next placed on the inclined surface to be inspected, which of course must lie in the same direction in which the zero setting was made the lever is loosened to disengage the adjusting worm from the graduated dial after which the vial and the dial are turned as one unit by means of the vial handle, until the air bubble is once more approximately centered.

The lever is then turned and the head and the worm shaft revolved until the air bubble is truly central. Now by reading the setting of the vernier through the eyepiece, the angular relation of this surface to the first surface can be determined.

Optical Centering Level

(Bausch & Lomb Optical Company)

IN setting up cylindrical work on a milling machine, much time is often spent in obtaining an accurate alignment of the cutter with the axis of the work and in checking this alignment. With but little practice a set up can be made with the aid of the centering level within a fraction of the usual time.



The instrument has a short horizontal vee and a long vertical vee. Above the short vee is a level vial, the air bubble of which is observed to determine the accuracy of a set up. In preparing to make a set up such as is illustrated, the centering level is placed on a machine table using the short vee as a base. If the table is not altogether level, the air bubble of the instrument, will, of course, be off center an amount that is readily determined by the graduations on the vial.

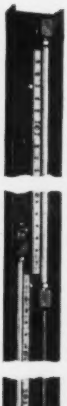
After the work has been properly set up and the cutter mounted on the arbor, the horizontal vee is placed on the cylindrical work with both sides of the vertical vee in contact with the cutter tooth. The cross slide of the machine is then operated backward or forward until the air bubble assumes the same position as when the vial was placed upon the table. A check to assure that the axis of the vee is perpendicular to the arbor axis is made by repeating this on the opposite side.

When this position has been obtained, the center line of the cutter teeth is in alignment with the axis of the work. In cases where the table is level, the air bubble of the device will, of course, be central in the vial when the work and cutter are correctly set up.

The same principle is used in setting up milling cutters, saws or drills.

Special Design Manometer

(Meriam Company)



The illustration shows a special type of U-tube mercury column manometer designed to measure pressures up to 50 lbs./in.^{2} is open to the atmosphere—or complete vacuum. It can also be suitable for measuring differentials on line pressures up to 500 lbs./in.^{2} The special construction shown is designed to eliminate the difficulty sometimes met with in attaching large precision instruments of this kind to the connecting pipes. ¶

Since the principle of a manometer depends upon the difference of liquid level in the 2 arms of the U-tube produced by the difference of pressure between the 2 ends of the tube, it is evident that the arms must in this case be about 100″ high. In order therefore to permit the manometer connecting union on the pressure side to be brought out at the middle instead of the top of the instrument, the upper part of one of the arms is omitted, and the pressure tube is connected to the usual gasketed union to a point a little above the normal zero line of the liquid. The other arm of the tube, being open to the atmosphere, needs no pipe attachment. This of course makes a neater and less expensive pipe job.

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CHECKING PYROMETERS & THERMOCOUPLES. Direct mail piece on the Treasure Chest—a potentiometer for checking pyrometers. Thwing Instrument Company, 3339 Lancaster Ave., Philadelphia, Pa.

GAS SERVICE JOURNAL. The April issue of this publication contains: New Orleans, The Cresent City, and Gas; Energy, Wild or Tame. Pittsburgh Equitable Meter Co., 400 Lexington Ave., Pittsburgh, Pa.

ENGINE INDICATOR VALVE. Bulletin 1266. Leaflet illustrates and briefly describes the Maihak Indicator Valve. Bacharach Industrial Instrument Co., 700 Bennett St., Pittsburgh, Pa.

KNOCK TESTING APPARATUS. Loose leaf folder describes and illustrates the knock testing apparatus developed by the Ethyl Gasoline Corporation Engineering Laboratory, 723 E. Milwaukee Ave., Detroit, Mich.

METERED COMBUSTION CONTROL. Leaflet entitled "Load Distribution is Flexible" illustrates the flexible regulation of the L & N combustion control. Leeds & Northrup Company, 4901 Stenton Ave., Philadelphia, Pa.

MICROAMMETER. Leaflet contains index to general catalogue. Sensitive Research Instrument Corp., 142 E. 32 St., New York, New York.

OPTICAL PYROMETER. Leaflet illustrates and describes self-contained storage battery disappearing filament pyrometer. This is printed in German. Hartmann & Braun, Frankfurt a/M., Germany.

POTENTIOMETER PYROMETER. Leaflets illustrate the ease of operation of L & N potentiometer pyrometers in Steel Mills, Malleable Annealing Plants and Chemical Plants.

PRECISION LATHE. Bulletin 18 gives detailed descriptions, illustrations and prices of complete line of 18″ geared screw cutting precision lathes and attachments. South Bend Lathe Works, 426 E. Madison Street, South Bend, Indiana.

RING BALANCE. Leaflet describes and illustrates the H & B ring balance for measuring pressure and volume. This is printed in English. Hartmann & Braun, Frankfurt a/M., Germany.

TECHNICAL INSTRUMENT BULLETIN. The March issue of this publication contains the following: Dark Ground Photographs of Living Micro-Organisms; A New Vertical Illuminator; The Creation of a Microscope Objective; An Early Microscope Illuminating System. Emil Busch Optical Co., Ltd., Diamond House, Hatton Garden, London E. C. 1, England.

MEASURING TOOLS. 400 page catalogue gives information on the products of the Goodell-Pratt Co. Complete Catalog No. 16. Goodell-Pratt Co., Greenfield, Mass.

WATER WORKS JOURNAL. The March issue of this publication contains: The Advantages of the Metered City in Dry Periods and Heat Waves; Emergency Truck and Money-Saving Trencher of the Portland Water District Pittsburgh Water Service is $65,000,000 Enterprise; Incinerator Plant at Niagara Falls. Pittsburgh Equitable Meter Company, 400 Lexington Ave., Pittsburgh, Pa.

IMMERSION PYROMETER. Bulletin No. 528 illustrates various models of the Pyro-Lance. Illinois Testing Laboratories, Inc., 141 West Austin Ave., Chicago, Ill.

X-RAY AND THE FOUNDRY. Bulletin discusses nature of X-rays and describes equipment. Kelley-Koett Mfg. Co., Inc., Covington, Kentucky.

TESTING SIEVES. Catalogue 53 entitled "The Profitable Use of Testing Sieves" includes information on various products of W. S. Tyler Co., Cleveland, Ohio.

METERED COMBUSTION CONTROL. Feature 14 is devoted to the automatic inlet valve and fan speed control; Feature 15 covers the electrically operated drives. Leeds & Northrup Company, 4901 Stenton Ave., Philadelphia, Pa.

WYE LEVEL. 52 page booklet gives instructions on how to use the "Sterling" convertible Wye level, Philadelphia model 40. Warren-Knight Co., 136 North 12 Street, Philadelphia, Pa.

FLUXMETER. Leaflet describes the Grassot fluxmeter for the measurement of field strength of permanent magnets. Cambridge Instrument Company, Inc., Grand Central Terminal, New York, N. Y.

TORSION DYNAMOMETER. Leaflet covers principle of operation, application and advantages of the Bamag torsion dynamometer. This is printed in German. Berlin-Anhaltische Maschinenbau A.-G., Dessau, Germany.

GAS ANALYSIS. List 144 describes the electric gas analyser and covers a number of the applications: Fixation of Atmospheric Nitrogen, Liquid Air Industry, Measurement of sulphur dioxide, organic vapors, oxygen in feed water, carbon dioxide in fruit stores, hydrogen in submarines, humidity, etc. Cambridge Instrument Company, Grand Central Terminal, New York, N. Y.

SURFACE PYROMETERS. List 194-S illustrates a number of models and their applications. Cambridge Instrument Co., Grand Central Terminal, New York, N. Y.

ELECTRIC FLOW METER INSTRUCTION BOOK. 40 page booklet, 8 x 10 inches, explains the mechanism of the various types of Brown flow manometers, indicators and recorders. It gives instructions for installing the equipment, adjusting the instruments for zero readings and changing the range tubes. Brown Instrument Company, 4482 Wayne Ave., Philadelphia, Pa.

VITREOUS-ENAMELED RESISTORS. GEA-1238 gives dimensions, watt ratings and resistance ratings. 18 pages. General Electric Company, Schenectady, N. Y.

FLUE GAS ANALYZERS. Catalogue TSE-30 covers flue gas analyzers and portable combustion test sets. The Hays Corporation, East 8th Street, Michigan City, Ind.

THERMIONIC VOLTMETERS. List 911 illustrates and describes various models. Cambridge Instrument Co., Grand Central Terminal, New York, N. Y.

ALTERNATING CURRENT INSTRUMENTS. List 162 contains information on inductance standards, low inductance resistances, condensers, vibration galvanometers, high frequency galvanometers, thermionic voltmeters, frequency meters, capacitance bridges, etc. Cambridge Instrument Co., Grand Central Terminal, New York, N. Y. A supplement to List 162 gives some methods of measuring inductance, capacitance and resistance.

HYDROGEN-ION MEASUREMENTS. List 108 furnishes information on the principle of operation and on the models available. Cambridge Instrument Co., Grand Central Terminal, New York, N. Y.

VOLTOHMMETER. Form 3030 describes the Service voltohmmeter for the radio service man or tester. Jewell Electrical Instrument Co., 1650 Walnut Street, Chicago, Ill.

LIGHT RELAYS. Leaflet 20412 contains detailed information on the light relay, a photo-electric light-sensitive device, operated by variations in light intensity. Westinghouse Electric & Mfg. Co., Newark Works, Newark, N. J.

CHECKING POTENTIAL TRANSFORMERS. Circ. 7160b-G is entitled "Should potential transformers be checked?" Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

LOAD RECORDERS HELP DISPATCHERS FOLLOW LOAD SCHEDULES. Circ. 7200b-G illustrates the L & N recorder for recording remote load. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

STEAM FLOW METER. Direct mail piece gives information taken from Bulletin 162 on Steam Flow Meters. Foxboro Company, Foxboro, Mass.

HIGH SPEED ENGINE INDICATOR. Leaflet describes an engine indicator for speeds up to 2500 per minute. This is printed in German. Lehmann & Michels, Abt. I, Hamburg-Altona, Germany.

MEAN PRESSURE INDICATOR. Leaflet describes the Geiger Pi-Meter, an instrument for determining the mean indicated pressure of piston engines. This is printed in German. Lehmann & Michels, Abt. I, Hamburg-Altona, Germany.

WATER WORKS JOURNAL. The April issue contains the following articles: Tulsa, Okla. Water Supply; Saving and Making Money by Accurate Metering of Water Consumption; Building an Ultra-Modern Water Supply System for Bridgeport. Pittsburgh Equitable Meter Company, 400 Lexington Ave., Pittsburgh, Pa.

MICROSCOPE OBJECTIVE. 20 page booklet is entitled "The Creation of a Microscope Objective in the Tathenow Works of the Emil Busch Optical Company. Emil Busch Optical Co., Ltd., 37 Hatton Garden, London, England.

RELAYS. Loose-leaf folder gives data and installation diagrams of contact relays, relay sets, instrument controlled relays, thermostats and series relays. Struthers Dunn, Inc., 139 North Juniper St., Philadelphia, Pa.

INSTRUMENT INVESTMENT NEWS. The May issue of this periodical contains the following: Temperature Control of Cotton Meal Cooking; Instruments in the Oil Fields. Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.

MEGOMER. Bulletin 195 shows the internal construction of the Paragon Megohmer. Herman H. Sticht & Co., 21 Park Row, New York, N. Y.

NAVIGATION LIGHTS. Leaflet illustrates these lights, also gives a brief description. Pioneer Instrument Company, 754 Lexington Ave., Brooklyn, N. Y.

GAS MEASUREMENT ENGINEERING. The May issue of this periodical contains: Two Recent Developments in Metering Equipment; Protector Type Siphon Gauges; and A New Application of Westcott Orifice Meters. American Meter Company, 105 West 40th Street, New York, N. Y.

SCOTT TESTERS. Loose leaf folder describes a calculating attachment for tensile tester, single strand yarn tester, combination automatic power yarn and cloth tester, serigraph, and combination tester for yarns, twines, cloth, paper, etc. Henry L. Scott Co., Providence, R. I.

Manometers

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CURRENT LITERATURE REVIEW

Abstracts on instruments and devices for measurement, inspection and control.

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GENERAL

Physical Society's Exhibition. III-V Electrical Review, Jan. 31, 1930, pages 226-228; Feb. 7, pages 267-268; Feb. 14, pages 324-325.

Descriptions of electrical instruments and scientific apparatus which were on display.—M. S.

An Electrical Telerecorder. A. H. Avery. Electrical Review, Jan. 24, 1930, pages 157-159.

Describes author's system for distant indicating and recording of measurements of steam flow, water level, pressure, temperature, etc. Is essentially a "dry" system, the action of which depends upon variable inductive effects in a transmitting coil situated in an alternating magnetic field. Any alternation of the plane of the rotor coil when it is within influence of the stator field results in inductive e.m.f.'s in the rotor windings proportional to the sine of the angle of rotation. Voltage values dependent upon the angular position of the rotor can then be transmitted with little error, owing to the minute current dealt with. Full equipment consists of a static transformer, voltage regulator, transmitter, integrator, and indicator-recorder.—M. S.

LENGTH, AREA, VOLUME

Ames Dial Micrometer. American Machinist, Feb. 6, 1930, page 281.

A micrometer having 2 dials, the smaller reading in 0.1″ and the larger in 0.001″ has been placed on the market by the B. C. Ames Company, Waltham, Mass. One division on the small dial marks one complete revolution of the hand on the hand on the large dial. The range of the micrometer is up to 1.″—R. H. P.

"United" Dial Caliper. American Machinist, Feb. 20, 1930, page 351.

This caliper uses an Ames dial indicator graduated to read in 0.01″ up to 2.″ One arm is detachable to permit replacing with a special arm to suit the requirements of the work.—R. H. P.

Device for Measuring Taper Holes. Harry W. Clifford. American Machinist, Feb. 27, 1930, page 384.

Describes a device for measuring the large diameters of taper holes in ring gages, dies, etc. If properly made it will check work within 0.0002.″ By a slight change in construction the instrument can be used for making external measurements.—R. H. P.

Electric Precision Gage of Great Accuracy. Machinery, Feb. 1930, page 435.

This instrument can be operated by an unskilled operator and measurements to 0.00005″ may be made. The gage is operated by the changing of the reluctance of a balanced, differential, alternating-current circuit, which in turn, operates a direct-current ammeter through a small rectifier. A smooth, rounded diamond point mounted on a single lever arm, changes the reluctance of the coils in the electric circuit in proportion to the differences in diameter of the piece being gaged.—R. H. P.

Multiple-Cutter Die for Graduating Micrometer Sleeves. Machinery, Feb. 1930, page 469.

A die designed to cut the 25 graduations on the tapered end of the micrometer sleeve.—R. H. P.

Progress Towards Legal Recognition of a Precise Inch Standard. William E. Bullock. Scientific Paper, American Institute of Weights and Measures, Jan. 1930, 13 pages.

The present status is discussed.

SURVEYING & NAVIGATION

Some Recent Developments in the Design and Construction of Surveying Instruments. W. H. Connell. Instrument World, March 1930, pages 297-300.

The developments made by Cooke, Troughton & Simms, Ltd. are described.

Bibliography of Surveying and Allied Subjects. Allgemeine Vermessungs Nachrichten, Dec. 25, 1929, 8 pages; Jan. 29, 1930, 8 pages.

Lists articles appearing in the current literature.

Bibliography of Surveying and Allied Subjects for Years 1928 & 1929. Zeitschrift fuer Vermessungswesen, Jan. 1, 1930, pages 67-73.

List articles appearing in the current literature.

SOLID, GRANULAR & POWDERED MATERIALS

Windsifter for the Determination of Grain Composition of Dust Like Materials (Windsichter zur Bestimmung der Kornzusammensetzung staubfoermiger Stoffe). Dr. H. W. Gonell. Tonindustrie Zeitung, Feb. 14, 1929, pages 247-249.

The apparatus is intended to meet the increased demands of industry for the determination of grain size of cement, powdered coal, dyes, metal dust, filling material for rubber, etc. Screening is limited to 60 and elutriating cannot be applied in all cases. The new apparatus, a wind-sifter which is illustrated and explained, goes down to smaller particle size, has no influence upon the material due to liquids or drying and is independent of temperature.—E. F.

LIQUIDS

Depth Gage for Measuring Liquids. Elton Sterritt. American Machinist, Jan. 2, 1930, page 25.

Twenty-two caliber cartridge shells are forced into holes bored at a 30° angle in a wooden measuring stick. These holes are at ¼″ intervals. The cartridge shells will fill to the depth of the liquid in the tank. This method is especially useful in the case of a volatile liquid which evaporates rapidly from a ordinary measuring stick.—R. H. P.

New Instruments, and Equipment to Control Water Consumption. (Neue Geraete und Einrichtungen fuer die Betriebsueberwachung von Wasserversergungsanlagen.) G. Eggers. Siemens-Zeitschrift, Dec. 1929, pages 835-845.

The article considers the measurements of water volumes, regulators for filters, quantity regulators for additional fluids, and the electric regulation of dampers in water tubes from a central switch board.—G. N.

Liquid-Storage Gauge. Electrical Review, Jan. 24, 1930, page 187.

Brief description of the "Nivex" gage, which records the exact quantity of liquid stored in a container. Principle of the system is that the pressure required to expel the liquid in a tube inserted in a vessel-is proportionate to the depth of liquid in the tube.—M. S.

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Depth Gauges
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Pitch Diameter Gauges
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29 North Sixth Street PHILADELPHIA, PA.

GASES, AIR & STEAM

Usage and Construction of the Dry Gas Meter. A. W. Sharman. Gas Journal, March 19, 1930, pages 764-766.

The operation of the Thomas Glover prepayment meter is explained.

ELECTRICITY

Causes of Errors of Electric Meters (Sur les causes d'inexactitude des compteurs électriques). J. Toupet, L'Industrie Électrique, Jan. 10, 1930, pages 16-18; Jan. 25, pages 41-44; Feb. 10, pages 67-70.

Published originally in Bulletin de l'Association des Propriétaires d'Appareils a Vapeur. Discusses the principal causes of errors and methods of avoiding them. They are grouped as those due to the type of meter or its characteristics, its condition, accessories, and method of installation.—M. S.

Measurement of Direct Currents of High Intensity (Le mesure des courants continus de forte intensite). P. Gonnard. Rev. Gen. de l'Electricite, Jan. 18, 1930, pages 95-101.

It is necessary to take special precautions to reduce the absolute value of the errors which arise in the measurement of the high current intensities used in electrochemical and electrometallurgical industries. Another describes a method of calibrating heavy current shunts, which are used in such measurements. It ultilizes two differential processes; one, that of flux opposition, devised by Pestarini, and improved by the method of magnetic correction, and the other, that of electromotive force opposition at the shunt terminals by the differential galvanometer.—M. S.

Some New Radio Instruments. Electrical Review, Feb. 14, 1930, pages 294-296.

Consists of extracts from 5 papers read before the Wireless Section of the Institution of Electrical Engineers. "A High-frequency Ammeter," by C. L. Fortescue and L. A. Moxon, describes the construction and theory of a simple form of hot-wire ammeter for use at frequencies up to 10^8 cycles per second. It is made in a cylindrical form. Each of six parallel wires is kept in its central position on the axis of a screening tube by means of a flat spring at the end. One of the wires is directly attached to what is normally the heated wire of an ordinary hot-wire ammeter. "Mechanical Impedance Measurement," by E. Mallett and R. C. G. Williams, outlines a method in which the device, the mechanical impedance of which is to be measured, is driven by one prong of a tuning-fork, and the other prong is loaded to restore balance. The load required is the mechanical impedance to be determined. "Response Curve Recording," by C. L. Fortescue and F. Ralph, describes the combination of a projection oscillograph with a special amplifier and a variable condenser coupled to the rocking mirror of the galvanometer, allowing the response curves of electrical circuits to be thrown on to a screen for observation or recording photographically.—M. S.

Instrument Progress in 1929. A. C. Jolley. Electrical Review, Feb. 7, 1930, pages 246-248.

Review of progress in the manufacture of electrical instruments as indicated by the twentieth exhibition of the Physical and Optical Societies. There have been no very bold steps or remarkable innovations, attention having been given to perfecting models shown previously, and particularly workmanship and interior finish.—M. S.

Design of a Portable Temperature-Controlled Piezo Oscillator. V. E. Heaton & W. H. Brattain, Bureau of Standards, Journal of Research, March 1930, pages 345-350.

This paper describes the essential details of a portable shielded temperature-controlled piezo oscillator constant in frequency to better than 1 part in 100,000. The quartz plate is mounted in a special plate holder so that the air gap changes very little as the quartz plate shifts in the holder. The plate holder is mounted in a thermal attenuating chamber consisting of a copper cylinder and layers of asbestos contained in a wooden box. The copper cylinder is mounted on heavy bronze coil springs to absorb shocks. A sensitive mercury thermostat, placed in a slot in the side of the copper cylinder, controls the temperature. The heater operates on 110 volts d.c. The quartz plate is connected between the grid and the filament of the oscillator tube. An inductor having a natural frequency slightly higher than that of the quartz plate is used in the plate circuit of the tube. The load is kept constant by loosely coupling to the output through a screen-grid radio-frequency amplifier. Measurements on the piezo oscillator give the following results: Temperature coefficient of 0.0025 per cent per degree centigrade; 10 per cent variation of plate or filament voltages from operating point of the oscillator tube causes less than 1 part in 1,000,000 change; jarring has no measurable effect on the frequency.

New Piezo Oscillations with Quartz Cylinders Cut Along the Optical Axis. August Hund and R. B. Wright. Bureau of Standards, Journal of Research, March 1930, pages 383-394.

It is shown that oscillations of a new type can be produced, using a quartz cylinder cut along the optical axis. Some of the electrode mountings used were suggested by Rontgen's experimental work and the more recent work of Tawil. In order to produce these oscillations it was necessary to use new adaptations of regenerative circuits as the driving circuit. These oscillations were studied experimentally through the medium of glow discharge patterns. a phemomenon of ionization produced by the quartz cylinder oscillating in a few millimeters of helium. They were studied theoretically by comparing the observed frequencies of oscillation with the computed values for the three different types or modes of vibration. Both studies indicate that these oscillations are of a true piezo-electric character.

Voltmeters from Milliammeters. Radio Service, April 1930, pages 6-7.

Article describes method for modifying milliammeters for dual purposes.

The Wheatstone Bridge in Service Work. James A. Dowie. Part I, Radio Service, April 1930, pages 12-13, 18.

Article describes use of Wheatstone Bridge for various measurements.

Finding Faults in Crippled Cables. E. J. Manuel. Synchroscope, April 1930, pages 48-51.

The early methods are briefly mentioned. Tracing current apparatus is illustrated.

An Electrical Frequency Analyzer. Masatsugu Kobayashi. Electrical Communication, April 1930, pages 315-319.

An electrical frequency analyzer for analyzing and recording so called higher harmonic waves as well as any waves comprising a number of frequencies, is described.

A Thousand-Cycle Frequency Standard. L. Armitage. Bell Laboratories Record, April 1930, pages 372-375.

Device is illustrated and briefly described.

The Measurement of Capacitance and Inductance in Terms of Frequency and Resistance at Radio Frequencies. C. P. Boner. Review of Scientific Instruments, April 1930, pages 243-259.

A method of measuring capacitance and inductance is described, in which the product LC is found in terms of frequency by adjusting a circuit which contains the capacitance and an inductance to resonance, the ratio L/C is found in terms of resistance by a high frequency bridge, and the value of C is finally calculated by solving the two equations for LC and L/C simultaneously. A method of eliminating the effect of condenser leads is described. The bridge equations are derived and the effects of residuals in the arms are discussed. Details are given concerning the construction of the bridge, the oscillators, and the heterodyne detector, and concerning essentials of the operating technique. Numerical results are given for a sample condenser calibration.

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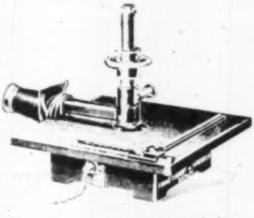

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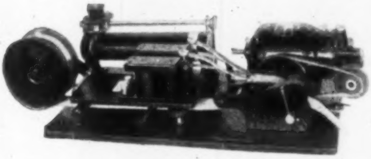

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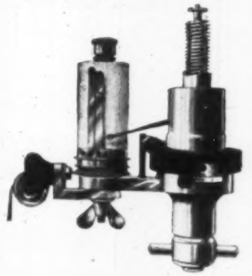

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Simplified Method of Accurate Meter Test. M. A. Mason, Electrical West, Jan. 1, 1930, pages 18-19.

Manipulation of double-pole double-throw switch introduced into meter leads gives complete check of three-phase meter connections without wire-tracing.—M. S.

Physical Society's Exhibition. Pt. 1-2. Electrical Review, Jan. 17, 1930, pages 139-140; Jan. 24, 1930, pages 182-183.

Review of some of the newer electrical instruments and scientific apparatus on display.—M. S.

Light and Speedy Portable Meter Test Set. W. L. Carr. Electrical World, Jan. 25, 1930, page 204.

The N. Y. Power & Light Corp. test set consists of a metal carrying case 19 x 8 x 9in. to contain the test equipment and tools. The test leads between the test meter and phantom load are intact within the case; the leads to connect to the watt-hour meter are very flexible, have a high grade rubber insulation and have clip contacts to be attached at the meter or test block. The outfit, complete; weighs about 24 lbs. and is suitable for testing meters up to 25-ampere capacity.—W. H. B.

Stabilized Oscilloscope with Amplified Stabilization. Frederick Bedell & Jackson G. Kuhn. Review of Scientific Instruments, April 1930, pages 227-236.

One stage of amplification included in the stabilizing circuit of the Bedell-Reich oscilloscope, which comprises a cathode-ray tube with linear time-axis for observation of periodically varying quantities, extends the frequency range of the instrument and permits stabilization without disturbance to the circuit under test. Although not primarily intended for use beyond the audio range, the instrument has in this way been stabilized above 100,000 cycles. Curves are given showing the use of the instrument for the study of non-electrical quantities (as sound and light) as well as of electrical quantities (as in the study of modulation and rectification).

Radio Receiver Performance. H. A. Thomas. Electrical Review, Jan. 24, 1930, pages 185-186.

Extract from paper read before Wireless Section of the Institution of Electrical Engineers. Describes an improved method of measuring overall amplification, which can be applied to practical cases, particularly at short wavelengths, and gives an analysis of the behavior of typical receivers. Elaborate screening of the various components is necessary. Potentiometer used is in the form of a straight resistance wire with a concentric turn.—M. S.

Cable-Testing Installation. Electrical Review, Jan. 31, 1930, pages 224-225.

Illustrated description of the plant and apparatus of the British Insulated Cables, Ltd., for testing the behavior of super-voltage cables. Principle involved in the tests is that of subjecting a cable to cyclic loading with superimposed voltage. Schering bridge is used for measuring dielectric loss and power factor.—M. S.

TEMPERATURE & MOISTURE

The "Pyroversum" Pyrometer. Iron & Coal Trades Review, Supplement, Dec. 6, 1929, pages III-IV.

This pyrometer is small enough to be carried in the pocket. It has a scale range from 500 to 1,400° C. The frame is calibrated in degrees C. A centerpiece of shaded glass graduated from clear to dead opaque in combination with a movable eyepiece make possible the direct reading of the temperature of the material being examined.—R. H. P.

HEAT UNITS & COMBUSTION

The Specific Heats of Gases at High Pressure. Method and Apparatus at Room Temperature. Norman W. Krase & B. H. Mackey. Journal American Chemical Society, Jan. 1930, pages 108-115.

A constant temperature continuous flow adiabatic calorimeter is described, and also the apparatus for measurement of the specific heats of gases at ordinary temperatures and up to 1000 atmospheres pressure. Typical results for nitrogen at 200 atm. are given.—M. E. H.

PRESSURE

Vapor Pressure of Toluene up to the Critical Temperature. Norman W. Crase & J. B. Goodman. Industrial & Engineering Chemistry, Jan. 1930, page 13.

Apparatus and methods for the measurement of vapor pressures were developed. Diagram is given.—M. E. H.

Determination of the Vapor Pressures of Napthas. J. C. Stauffer, J. K. Roberts & W. G. Whitman. Industrial & Engineering Chemistry, Analytical Edition, Jan. 15, 1930, pages 88-91

Presented before the Division of Petroleum Chemistry at the Minneapolis Meeting of the American Chemical Society, Sept. 1929. Measured amounts of dry air are bubbled through a sample and the increase in vapor volume is measured. Apparatus is described.—M. E. H.

Vapor Pressures of Saturated Equilibrated Solutions of Lactose, Sucrose, Glucose and Galactose. E. O. Whittier & S. P. Gould. Industrial & Engineering Chemistry, Jan. 1930, pages 77-78.

The static method of Smith and Menzies (Jl. Amer. Chem. Soc. 32, 1412, 1910) was used for determining the vapor pressures of saturated solutions. Diagram is included.—M. E. H.

Flow Manometer with A. C. Remote Indication (Stroemungsmanometer mit wechselstromfernuebertragung). H. Lohmann & F. von Grindherr. Siemens Zeitschrift, Jan. 1930, pages 37-43.

Description of a system of instruments for measuring quantities under application of a distant transmission by means of an alternating current.—G N.

On the Possibility of Applying the Cathode-Ray Oscillograph to the Indicator for High Speed Engines. J. Obata & Y. Munetomo. Report No. 57, Aeronautical Research Institute, Toyko Imperial University, Feb. 1930, pages 93-100.

Investigations were made to employ the cathode-ray oscillograph in place of the usual Duddell oscillograph in the electrical indicator described in the previous paper. It is found that the Johnson type cathode-ray oscillograph may be employed with some modifications of the electrical arrangement; special device being introduced to indicate the piston position. Photographic record of the indicator diagram can be obtained for those engines, for which the point-to-point indicator such as the R. A. E. indicator (or Farnborough type) gives satisfactory results.

SPECIFIC GRAVITY, DENSITY & WEIGHING

Determination of Alcohol by Pycnometer. Alex F. Fuerst. Industrial & Engineering Chemistry Analytical Edition, Jan. 15, 1930, page 30.

The method is based on the apparent uniform expansion of dilute alcohol (up to about 4.5 to 5.0%) and distilled water. Results are accurate to 0.01%.—M. E. H.

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PHYSICAL TESTING

Testing of Wood Glue (Pruefung von Tischlerleimen nach Rudeloff). J. Stamer, Wirtschaftliche Technik, Dec. 1929, pages 227-228.

Method described and illustrated.

Laboratory Tests Aid Tool Development. Charles O. Herb. Machinery, Feb. 1930, pages 425-429.

Discusses the use of the Olsen compression testing machine, Brinell microscope, Rockwell hardness tester, Scleroscope and other instruments. The Morse Twist Drill and Machine company, New Bedford, Mass. use these instruments to test the materials used in the production of their metal cutting tools.—R. H. P.

Small Wire Tension Tester with Pendulum. Wire & Wire Products, Feb. 1930, pages 55, 60.

The machine, built by Losenhausen Werke, Düsseldorff, Germany, has a capacity up to 10,000 lbs. and a double reading range from 0 to 10,000 lbs. and from 0 to 2000 lbs. The machine is equipped with special patented grip heads for rapid and easy handling and an elongation indicator.—G. N.

Transverse Tests of H-Section Column Splices. James H. Edwards, H. L. Whittemore & A. H. Stang. Bureau of Standards Journal of Research, March 1930, pages 395-413.

Plates were welded to the outer edge of the inside faces of the flanges of 3-foot lengths of 10, 12, and 14 inch H sections. The H sections were joined in pairs by splice plates bolted to these welded plates to represent a spliced section of column for use in a steel frame building. The specimens so formed were tested as beams on a 66-inch span with loads at the quarter points. Four specimens were tested with the splice plates and H section webs parallel to the applied loads which were in a vertical plane; three specimens were tested with the splice plates and H section webs perpendicular to the applied loads. The behavior of the specimens is described and a method of stress analysis suitable for use in designing similar splices is developed.

VIBRATION, SOUND, LIGHT, COLOR

A Photocolorimeter (Un Photocolorimétre). Ch. Féry. L'Industrie Électrique, Jan. 10, 1930 pages 18-19.

From the Bulletin de la Société d'Encouragement. Report to the Society on the Toussaint photocolorimeter, which consists of a photo-electric cell combined with a very sensitive d'Arsonval galvanometer. Give results of tests carried out with it.—M. S.

The Problem of Dilution in Colorimetric H-Ion Measurements. II. Use of Isohydric Indicators and Superpure Water for Accurate Measurement of Hydrogen-Ion Concentrations and Salt Errors. S. F. Acree & Edna H. Fawcett, Industrial & Engineering Chemistry, Analytical Edition, Jan. 15, 1930, pages 78-85.

Presented before the Division of Water, Sewage and Sanitation Chemistry at the Columbus Meeting of the American Chemical Society, April 1929. A method is given for the adjustment of the pH of the indicator standards against 0.001M or 0.05M buffer-color standards. The technic for the use of the isohydric indicator method is described.—M. E. H.

Evaluation of the Contrast-Obliterating and Brightening Power of White Pigments. George S. Haslam. Industrial & Engineering Chemistry, Analytical Edition, Jan. 15, 1930, pages 69-72.

Presented before the Division of Paint and Varnish Chemistry at the Minneapolis Meeting of the American Chemical Society, Sept. 1929. The equipment used consists of a black glass square of known brightness, a set-up for spinning uniform films of sample, a balance for weighing the panel before and after spinning, and the Pfund colorimeter for determining the brightness of the film. The data indicate that the value at which the eye is capable of detecting contrast is less than the generally accepted 98%.—M. E. H.

Experimental Determination of Brightness—Film Thickness Curves of Wet Paints. D. L. Gamble & A. H. Pfund. Industrial & Engineering Chemistry, Analytical Edition, Jan. 15, 1930, pages 63-66.

This paper discusses a method of extreme accuracy for the experimental determination of the brightness-film thickness relation, using a Macbeth photometer for measuring the brightness and the channeled spectrum phenomenon in determining film-thickness values. Data obtained by this method check quite closely values obtained with the Pfund cryptometer.—M. E. H.

A Portable Seismograph for Recording Earth Tremors Caused by Artificial Explosions. J. H. Jones. Instrument World, April 1930, pages 321-325.

Article describes instrument developed by the Technical Staff of the Anglo-Persian Oil Co., Ltd.

CHEMICAL APPARATUS & ANALYSIS

An Improved Weight Buret. Harold B. Friedman & Victor K. LaMer, Industrial & Engineering Chemistry, Analytical Edition, Jan. 15, 1930, page 54.

This burette has a capacity of 60cc., and terminates in a horizontal stopcock with a ground tip to which is fitted a guard.—M. E. H.

New Laboratory Oven. Canadian Chemistry & Metallurgy, March 1930, page 92.

The new Freas Thermo Electric Co. ovens have horizontal flow force air circulation which permits the use of shelves and trays without obstructing air circulation. They afford greater speed in baking and drying operations under controlled heat. The frame work is welded structural steel, insulation is secured through double walls of high thermo-resistivity, heaters are nickel-chromium alloy, and the intake and exhaust in air is controlled by adjustable shutters on the vent and air ports.—W. H. B.

Rapid Determination of Nitrogen Peroxide in Nitrogen Peroxide-Air Mixtures. Colin W. Whittaker, F. O. Lundstrom & Albert R. Merz. Industrial & Engineering Chemistry, Analytical Edition, Jan. 15, 1930, pages 15-18.

A rapid method is outlined and apparatus described. Briefly, the volume of sample is measured at 156.2° C., the nitrogen peroxide is absorbed in concentrated sulphuric acid, and the residual gas is measured in a gas burette at room temperature.—M. E. H.

A Photochemical Method for Measuring Susceptibility of Fats and Oils to Oxidation. George R. Greenbank & George E. Holm. Industrial & Engineering Chemistry, Analytical Edition Jan. 15, 1930, pages 9-10.

The photoelectric cell with amplifying unit was used in this investigation, and the results compared with the induction period method (direct oxygen absorption) and found directly comparable.—M. E. H.

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FUEL ANALYSIS APPARATUS
Burgess-Parr Co.
FUEL FLOW INDICATOR
Commercial Engg. Labs.
GALVANOMETERS
Brown Instrument Co.
Charles Engelhard, Inc.
General Radio Co.
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Rubicon Company
Westinghouse Elec. & Mfg. Co.
Weston Electrical Inst. Corp.
GAS ANALYTICAL METERS
Chemical
American Meter Co.
Tagliabue Mfg. Co., C. J.
Electrical
Brown Instrument Co.
Charles Engelhard, Inc.
Leeds & Northrup Co.
GAS LEAK INDICATORS
Taylor Instrument Companies
GAS-METERS
American Meter Co.
Brown Instrument Co.
Foxboro Co.
Meriam Co.
GASOMETERS
American Meter Co
GAGE RODS
Tagliabue Mfg. Co., C. J.
GAGES
Absolute Pressure
Bristol Company
Brown Instrument Co.
Foxboro Co.
Meriam Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Amplifying
B. C. Ames Co.
Federal Products Corp.
Comparator
B. C. Ames Co.
Federal Products Corp.
Cylinder
B. C. Ames Co.
Federal Products Corp.
Depth
B. C. Ames Co.
Federal Products Corp.
Dial
B. C. Ames Co.
Federal Products Corp.
H. Z. Schniewind
Differential Pressure
American Meter Co.
Brown Instrument Co.
Foxboro Co.
Meriam Co.
Tagliabue Mfg. Co., C. J.
Draft
Bristol Company
Brown Instrument Co.
Foxboro Co.
Meriam Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Drill
Bausch & Lomb Optical Co.
Grinding
Federal Products Corp.
Liquid Level
Bristol Company
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.
Meriam Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Loss of Head
Brown Instrument Co.
Foxboro Co.
Meriam Co.
Pitch Diameter
Federal Products Corp.
Pocket
H. Z. Schniewind
Pressure
American Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.
Meriam Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Pressure-Temperature
Bristol Company
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Cos.
Pressure & Vacuum
Bristol Company
Brown Instrument Co.
Charles Engelhard, Inc.
Foxboro Co.
Leeds & Northrup Co.
Meriam Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Profile
Bausch & Lomb Optical Co.
Rain
Taylor Instrument Companies

Determination of Acidity of Oils and Fats by the Quinhydrone Electrode in Non-Aqueous Solutions. Harry Seltz & Louis Silverman. Industrial & Engineering Chemistry, Analytical Edition, Jan. 15, 1930, pages 1-2.

It has been found that a silver-silver chloride electrode functions satisfactorily as a reference electrode and can be used for numerous determinations without deterioration. The method was found to be applicable not only to mineral oils but also to vegetable and animal oils and fats. Methods of preparing the electrode is given.—M. E. H.

Synthetic Glycerides. II. Refractive Indices of Glycerides of Known Constitution. H. P. Averill, J. N. Roche & C. G. King. Journal American Chemical Society, Jan. 1930, pages 365-367.

Apparatus was devised for using an immersion refractometer in a constant temperature bath at a range of 65-78 degrees. Diagram is given.—M. E. H.

The Behavior of Glass Electrodes of Different Compositions. D. A. MacInnes & Malcolm Dole. Journal American Chemical Society, Jan. 1930, pages 29-36.

Using a form of glass electrode designed by the authors, the suitability of a series of specially prepared glasses for use as electrodes has been studied. The best of the glasses tested has the composition SiO_2, 72, Na_2O, 22, and CaO, 6%. The potential at the surface of this glass changes quantitatively with the H-ion activity up to pH values of 9.5.—M. E. H.

A Comparison Method for Determining Ionization Constants with a Quinhydrone Reference Electrode. H. Darwin Kirschman, Baker Wingfield & Howard J. Lucas. Journal American Chemical Society, Jan. 1930, pages 23-28.

Ionization Constants of organic acids may be determined by means of a quinhydrone cell in which the reference half-cell is standard hydrochloric acid solution saturated with quinhydrone and containing potassium chloride. The method is tested in the case of benzoic acid by a comparison of the values herein obtained with those reported by others and found to be in satisfactory agreement. —M. E. H.

Application in Burgess-Parr Sulfur Photometer to Rapid Determination of Sulfur in Foods and Biological Material. Edward W. Toepfer & Paul W. Boutwell. Jan. 15, 1930, pages 118-121.

The sulphur in the oxidized sample may be quickly determined by the use of the Burgess-Parr sulphur photometer, which depends upon the formation of colloidal barium sulphate. This paper was presented before the Division of Agriculture and Food Chemistry at the Minneapolis Meeting of the American Chemical Society, Sept. 1929.—M. E. H.

Quantitative Hydrogenation of the Principal Unsaturated Components of Turpentine, Pine Oil and Rosin. W. E. Shaefer. Industrial & Engineering Chemistry, Analytical Edition, Jan. 15, 1930, pages 115-117.

A simple and accurate method for quantitative hydrogenation at ordinary temperature and atmospheric pressure with palladium as catalyst is described. This should prove of value in the study of pure compounds of unknown constitution.—M. E. H.

Determination of Sulphur in Gasoline. Graham Edgar & George Calingaert. Industrial & Engineering Chemistry, Analytical Edition, Jan. 15, 1930, pages 105-106.

Several modifications of the standard apparatus for the determination of sulphur in gasoline are described. These devices seem to have certain advantages over the standard (A. S. T. M.) method. —M. E. H.

Observations on the Rare Earths—XXXIV Spectrographic Estimation of Impurities in the Rare Earths. Pierce W. Selwood. Industrial & Engineering Chemistry, Analytical Edition, Jan. 15, 1930, pages 93-96.

The applicability has been demonstrated of the spectrographic method to the detection and estimation of traces of Mn, Mg, Ca, Ba, Si, Bi, Al, Be, samarium and gadolinium in neodymium, and of lanthanum in yttrium.—M. E. H.

The Oxidation Potential of the Lead Dioxide Electrode in Perchloric Acid Solution. D. J. Brown & John C. Zimmer. Journal American Chemical Society, Jan. 1930, pages 1-6.

The standard oxidation potential of Pb-ion-PbO_2 in molal H-ion has been measured by two methods and found to be 1.467 ± 0.003 volts.—M. E. H.

A New Application of the Abbé Refractometer in the Analysis of Lacquer Thinners. J. D. Jenkins. Industrial & Engineering Chemistry, Analytical Edition, Jan. 15, 1930, pages 127-128.

Presented before the Division of Paint and Varnish Chemistry at the Minneapolis Meeting of the American Chemical Society, Sept. 1929. The use of the dispersion scale on an Abbé refractometer has been found to be a rapid and comparatively accurate method of determining the toluene or benzene content of lacquer thinners. The dispersion readings of the aliphatic compounds average close to 41.4, while the readings for aromatic hydrocarbons fall very near 35.6. For mixture the scale readings bear a straight line relation to the volume composition—M. E. H.

MICROSCOPY

Some Uses of the Microscope in Industry. Instrument World, April 1930, pages 327-328, 330.

The applications of the microscope are briefly considered.

A British Maker of Microscopes. Instrument World, April 1930, pages 329-330.

The plant of W. Watson & Sons, Ltd. is described.

New Microscope and Attachment Designs. Canadian Chemistry & Metallurgy, March 1930, page 92.

A new research microscope of the Bausch & Lomb Optical Co., Rochester, N. Y. has binocular eyepieces in inclined position with the stage directly in front of the operator. Much weight is taken off the adjustment parts—important for work at high magnifications or in long exposures in photomicrographic work. A novel feature of the substage is a supplementary condenser on a swing arm. A new type of lamp utilizes the full aperture of the microscope condenser and transmits sufficient light to make possible critical illumination of the specimen.—W. H. B.

Microscopic Examination of Precipitates as an Aid to Precise Analysis. I-Estimation of Sulfates as Barium Sulfate. Stephen Popoff & E. W. Neuman. Industrial & Engineering Chemistry, Jan. 15, 1930, pages 45-54.

Photomicrographs of barium sulphate obtained under varying conditions and methods show that the reverse procedure of adding the sulphate to the acidified barium chloride solution, gives in practically all cases more uniform crystals and more nearly the same kind of crystals than other recommended methods.—M. E. H.

The Polarizing Microscope in Organic Chemistry. H. C. Benedict, Industrial Engineering Chemistry, Analytical Edition, Jan. 15, 1930, pages 91-93.

Bibliography of 32 references. This article points out the usefulness and the possibilities of the polarizing microscope, which the author hails as a time and labor saver in organic chemistry. Numerous examples are cited to substantiate his statement.—M. E. H.

Recording
Distance
Bristol Company
Brown Instrument Co.
Esterline-Angus Company
Foxboro Co.

Strain
Southwark Fdry. & Mach. Co

Thickness
B. C. Ames Co.
Esterline-Angus Company
H. Z. Schniewind

Volume
American Meter Co.
Brown Instrument Co.
Foxboro Co.
Meriam Co.
Water Level for Boilers
Bristol Company
Brown Instrument Co.
Foxboro Co.
Wind
Brown Instrument Co.
Taylor Instrument Companies
GEOPHYSICAL INSTRUMENTS
Akatos, Inc.
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American Meter Co.
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Bristol Company
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Tagliabue Mfg. Co., C. J.
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Rubicon Company
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Weston Electric Inst. Corp.
GROUND-OHMER
Leeds & Northrup Co.
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H. Z. Schniewind
Wilson-Maeulen Company, Inc.
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Leeds & Northrup Co.
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HIGH FREQUENCY APPARATUS
Argco Laboratories, Inc.
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Indicators
Argco Laboratories, Inc.
Measuring Devices
Westinghouse Elec. & Mfg. Co.
Testing Devices
Westinghouse Elec. & Mfg. Co.
HUMIDITY CONTROLLERS
Bristol Company
Charles Engelhard, Inc.
Foxboro Co.

HUMIDITY RECORDERS
Wet & Dry Bulb Thermometers
Bristol Company
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

HYDROGEN ION METERS
Indicating
Leeds & Northrup Co.
Rubicon Company
Controlling, Recording
Leeds & Northrup Co.

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Taylor Instrument Companies
HYGROMETERS
Brown Instrument Co.
Foxboro Co.
H. Z. Schniewind
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
IMPACT HARDNESS TESTER
H. Z. Schniewind
IMPACT TESTING MACHINES
Akatos, Inc.
H. Z. Schniewind
Alternating
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INDUCTANCES
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Instruments Publishing Co.

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INSTRUMENT TRANSFORMERS
Jewll Electrical Instrument Co.
Westinghouse Elec. & Mfg. Co.
Weston Electrical Inst. Corp.
INSULATION TESTING EQUIPMENT
Leeds & Northrup Co.
Rubicon Company
Westinghouse Elec. & Mfg. Co.
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General Radio Co.
Leeds & Northrup Co.
Rubicon Company
KILNBOY
Foxboro Co.
KILOVOLT AMPRERE METERS
Esterline-Angus Company
KLYDONOGRAPHS
Westinghouse Elec. & Mfg. Co.
LACTOMETERS
Tagliabue Mfg. Co., C. J.
LENGTH MEASURING MACHINES
Gaertner Scientific Corp.
H. Z. Schniewind
LEVELS
Centering
Bausch & Lomb Optical Co.
Enginerr's, Wye, Precision
Prism
Taylor Instrument Companies

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LUSTER METERS
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MANOMETERS
American Paulin System, Inc.
Brown Instrument Co.
Foxboro Co.
Meriam Co.
MASTER CLOCKS
Gaertner Scientific Corp.
Stromberg Electric Co.

MEASUREMENT BOOKS
Instrument Publishing Co.

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Rubicon Company
Herman H. Sticht and Company
MEGOHM VOLTMETERS
Jewell Electrical Instrument Co.
Weston Electrical Inst. Corp.

MELTING POINT APPARATUS
Tagliabue Mfg. Co., C. J.

METER PROVERS, Gas
American Meter Co.
METER TESTERS, Gas
American Meter Co.

MICROMETERS
Gaertner Scientific Corp.
H. Z. Schniewind

MICROAMMETERS
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Rawson Electrical Instrument Co.
Weston Electrical Inst. Corp.
Wilson-Maeulen Company, Inc.

MICROFARADMETERS
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Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Rubicon Company
Weston Electrical Inst. Corp.

MICRO PYROMETERS
Akatos, Inc.

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Gaertner Scientific Corp.
H. Z. Schniewind
Spencer Lens Co.
Metallographic
Akatos, Inc.
Bausch & Lomb Optical Co.
Spencer Lens Co.
Petrographical
Akatos, Inc.
Bausch & Lomb Optical Co.
Spencer Lens Co.
Toolmakers'
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.
Spencer Lens Co.

MICROTOMES
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Spencer Lens Co.

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General Radio Co.
Jewell Electrical Instrument Co.
Rawson Electrical Instrument Co.
Weston Electrical Inst. Corp.
Wilson-Maeulen Company, Inc.

MILLIVOLTMETERS
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Charles Engelhard, Inc.
Jewell Electrical Instrument Co.
Rawson Electrical Instrument Co.
Taylor Instrument Companies
Weston Electrical Inst. Corp.
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Minneapolis-Honeywell Co.
MOTION RECORDERS
Mechanical
Bristol Company
Lehmann & Michels
MULTIMETERS
Rawson Electrical Instrument Co.
MULTIPLIERS
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Weston Electrical Inst. Corp.
NEON FILLED TUBES
Argco Laboratories, Inc.
NEPHELOMETERS
Akatos, Inc.
OHM METERS
General Radio Co.
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Rawson Electrical Instrument Co.
Rubicon Company
Herman H. Sticht and Company
Weston Electrical Inst. Corp.
OIL TESTING APPARATUS
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Microscopic Measurements for the Determination of Particle Size of Pigments and Powders. E. J. Dunn, Jr., Industrial & Engineering Chemistry, Analytical Edition, Jan. 15, 1930, pages 59-63.

Images of the particles are projected through a microscope onto a screen, where the particles are measured and classified. Changing the focus, by remote control, facilitates the work and permits the accurate measurement of each particle throughout the depth of the mount.—M. E. H.

Don't Be Afraid of the Microscope. E. R. Schwarz. Textile World, Oct. 26, 1929, pages 2430-2434, 2445; Dec. 14, 1929, pages 4364-4366, 4405; Dec. 21, 1929, pages 4500-4503.

Article describes methods and equipment needed to carry out micrometer examination of textiles, mounting of textile specimens; discusses selection of glass slides and chemicals.

The Vickers Projection Microscope. Iron & Coal Trades Review, Supplement, Dec. 6, 1929, page 11.

This microscope may be used for transparent or opaque objects. Illumination may be had by transmitted, polarized or reflected light. The specimen may be examined by the ordinary visual method or it may be projected upon a ground-glass screen. The latter may be replaced by a dark slide to secure a photomicrograph.—R. H. P.

VISCOSITY

Rapid Determination of Relative Viscosity of Opaque Liquids. Milton M. Loeserman. Industrial & Engineering Chemistry, Analytical Edition, Jan. 15, 1930, page 25.

The article describes a modification of the bubble method.—M. E. H.

Viscosity of Beet House Sirups. A. N. Bennett & A. R. Nees. Industrial & Engineering Chemistry, Jan. 1930, pages 91-96.

The design and use of a falling sphere viscometer for the determination of the absolute viscosity of pure and impure sugar solutions are described. The effect of pH on viscosity of molasses has been investigated.—M. E. H.

Viscosity of Solutions. G. Jones & M. Dole. Nature, Nov. 30, 1929, page 857.

Originally in Journal American Chemical Society, Oct. 1929. The fluidity of a solution may be represented by an expression containing the concentration to the powers 1 and 1½. The coefficient of the square root term is negative for electrolites, but zero for nonelectrolites.—Abs. Bull. Kodak Res. Labs.

Theory of Plastic Flow in the Rotation Viscometer. M. Reiner, Journal of Rheology, Oct. 1929, pages 5-10.

The author derives an equation for the consistency function for a plastic material in rotation viscometer. No data are given.—Abs. Bull. Kodak Res. Labs.

Modified Plastometer for Industrial Use. D. V. Gregory, G. M. Rassweiler & K. C. Lampert. Journal of Rheology, Oct. 1929, pages 30-45.

A modified Bingham plastometer has been built involving the use of capillary tubes but differing in that the material is sucked through the tube instead of being forced. Relations are given for the readings obtained with the plastometer and other methods employed for determining viscosity and plasticity, such as the Cargelle bulb viscometer, mobilometer, etc.—Abs. Bull Kodak Res. Labs.

A Multiple Bulb Consistometer. W. Herschel. Journal of Rheology, Oct. 1929, pages 68-75.

An apparatus has been designed involving the use of a capillary that can be used for either viscous or plastic substances. It is claimed that a complete flow pressure graph can be made from one run.—Abs. Bull. Kodak Res. Labs.

PHOTOGRAPHY

Special Camera Makes a Photographic Stop Watch Record. Filmtechnik, Aug. 4, 1928, pages 328-329.

The Laytax motion picture measuring camera is a Lyta camera so modified as to make exposure two frames in height. It also incorporates a prism device for photographing a watch face in the lower corner of the negative. Either an ordinary watch or a stop watch may be used. The camera operates at 50 exposures per second.—Abs. Bull. Kodak Research Labs.

A Method of Identifying Precious Stones. American Photography. April 1930, pages 192-195.

A photographic method is described.

SPECIAL

Measurement of the Leveling Properties of Paints and Enamels. George S. Haslam & Lester D. Grady, Jr., Industrial & Engineering Chemistry, Analytical Edition, Jan. 15, 1930, pages 66-69.

This paper shows that the leveling properties are not entirely expressed by consistency measurements. The du Noüy tensiometer is suggested as an instrument for measuring the leveling properties. Comparison of tensiometer results, with results of five consistency measuring devices shows the superiority of the tensiometer method.—M. E. H.

Dilatometer, Modified: II. A Method for Determining Transition Temperatures of Gels and Sols. Harvey A. Neville, Edwin R. Theis & C. T. Oswald. Industrial & Engineering Chemistry, Jan. 1930, pages 60-63.

A modified dilatometer, by means of which the gelation and melting temperatures of gelatin solutions can be determined under carefully controlled conditions, is described. By this method continuous readings are obtained and the gel structure is not disturbed during the process.—M.E.H.

Dilatometer: A Study of Some Properties of Gelatin. I-Hydration of Gelatin and Its Relation to Swelling. Harvey A. Neville, Edwin R. Theis, & R. B. K'Burg. Industrial & Engineering Chemistry, Jan. 1930, pages 57-60.

The dilatometer consists of a bottle with a ground glass stopper, through which is sealed a calibrated capillary tube. Diagram is given.—M. E. H.

A Simplified Goodrich Plastometer. E. Karrer, J. M. Davies & E. O. Dieterich. Industrial & Engineering Chemistry, Analytical Edition, Jan. 15, 1930, pages 96-99.

Presented before the Division of Rubber Chemistry of the American Chemical Society at Atlantic City, Sept. 1929. The article describes a simplified form of the Goodrich plastometer, for factory-control use, and discusses the use of the instrument in measuring plasticity of rubber.—M. E. H.

Testing Welds for Strength and Quality. Machinery, Feb. 1930, pages 463-466.

Two general classes of tests are applied to welds; destructive and non-destructive. Both of these are discussed in this article, each from two viewpoints, that of the instruments and equipment used in the tests, and the information secured from these tests. Describes a hydrostatic test, stethoscope test, X-ray test, and several others.—R. H. P.

MISCELLANEOUS

Miscarta Cases for Portable Instruments are Attractive, Light and Durable. Paul MacGahan. Electric Journal, March 1930, pages 176-177.

Micarta, a new material, affords appreciable reduction in size of the case and offers greater resistance to scratching. Several illustrations of micarta instrument cases are shown.—W. H. B.

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Brown Instrument Co.
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Brown Instrument Co.
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Gaertner Scientific Corp.
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Westinghouse Elec. & Mfg. Co.
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Brown Instrument Co.
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Automatic Flow Record
Brown Instrument Co.
Linear
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Square Root
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Leeds & Northrup Co.
Rubicon Company
Recording & Controlling
Foxboro Co.
Leeds & Northrup Co.

POWER FACTOR METERS
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Jewell Electrical Instrument Co.
Westinghouse Elec. & Mfg. Co.
Weston Eelectrical Inst. Corp.

POWER FACTOR REGULATORS
Rubicon Company
Westinghouse Elec. & Mfg. Co.
PRESSURE RECORDERS
Esterline-Angus Company
PRICESS TIMING AND SIGNALING INSTRUMENTS
Stromberg Electric Co.
PROGRAM INSTRUMENTS
Stromberg Electric Co.
PROJECTION LANTERNS
Bausch & Lomb Optical Co.
Spencer Lens Co.
PROTRACTOR
Optical
Bausch & Lomb Optical Co.

PSYCHROMETER
Recording
Bristol Company
Foxboro Co.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Sling
Taylor Instrument Companies

PYROMETERS
Optical
Leeds & Northrup Co.
Pyrometer Instrument Company
Radiation
Indicating
Brown Instrument Co.
Leeds & Northrup Co.
Pyrometer Instrument Company
Taylor Instrument Companies
Recording
Brown Instrument Co.
Leeds & Northrup Co.
Taylor Instrument Companies

Thermo-electric
Immersion
Bristol Company
Brown Instrument Co.
Charles Engelhard, Inc.
Leeds & Northrup Co.
Pyrometer Instrument Company
Taylor Instrument Companies
Wilson-Maeulen Company, Inc.
Indicating
Bristol Company
Brown Instrument Co.
Charles Engelhard, Inc.
Leeds & Northrup Co.
Taylor Instrument Companies
Westinghouse Elec. & Mfg. Co.
Wilson-Maeulen Company, Inc.
Recording and Controlling
Bristol Company
Brown Instrument Co.
Charles Engelhard, Inc.
Leeds & Northrup Co.
Taylor Instrument Companies
Wilson-Maeulen Company, Inc.
Surface Contact
Bristol Company
Brown Instrument Co.
Charles Engelhard, Inc.
Leeds & Northrup Co.
Pyrometer Instrument Company
Taylor Instrument Companies
RADIO FREQUENCY OSCILLATORS
General Radio Company
RADIO SET ANALYZERS
General Radio Company
Jewell Electrical Instrument Co.
Weston Electrical Inst. Corp.
RADIO TUBE CHECKERS
General Radio Company
Jewell Electrical Instrument Co.
Weston Electrical Inst. Corp.
RADIO TEST PANEL
Jewell Electrical Instrument Co.
Weston Electrical Inst. Corp.
REFRACTOMETERS
Akatos, Inc.
Bausch & Lomb Optical Co.
Spencer Lens Co.

REGULATORS—See Controls
RELAYS
General Radio Co.
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Westinghouse Elec. & Mfg. Co.
Weston Electrical Inst. Corp.
REMOTE METERING EQUIPMENT
Bristol Company
Brown Instrument Co.
Leeds & Northrup Co.
Westinghouse Elec. & Mfg. Co.
RESISTANCES—Electrical
General Radio Co.
Leeds & Northrup Co.
Spencer Lens Co.
RHEOSTATS
General Radio Co.
Rubicon Company
Spencer Lens Co.
ROTOSCOPE
Commercial Engg. Labs.
RUBBER TESTING INSTRUMENTS
H. Z. Schniewind
SACCHARIMETERS
Akatos, Inc.
Bausch & Lomb Optical Co.
Spencer Lens Co.
Taylor Instrument Companies
SACCHROMETERS
Tagliabue Mfg. Co., C. J
SALINITY INDICATORS
Rubicon Company
SCALES
Amthor Testing Instrument Co.
Gaerther Scientific Corp.
H. Z. Schniewind
SCRATCH HARDNESS TESTER
SEISMOGRAPHS
Akatos, Inc.
SERVICE RECORDERS
Esterline-Angus Company
SHUNT METERS
SHUNTS
Esterline-Angus Company
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Rubicon Company
Weston Electrical Inst. Corp.
SIGNALLING DEVICES—Automatic
Brown Instrument Co.
Stromberg Electric Co.
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SOIL PRESSURE CELLS
SPECIAL INSTRUMENTS
Burgess-Parr Co.
Meriam Co.
H. Z. Schniewind
SPECIAL ELECTRICAL INSTRUMENTS
Brown Instrument Co.
Charles Engelhard, Inc.
Esterline-Angus Company
General Radio Co.
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Rawson Electrical Instrument Co.
Rubicon Company
Weston Electrical Inst. Corp.
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SPECIFIC GRAVITY APPARATUS
Gas,
American Meter Co.
SPECTROGRAPHS
Gaertner Scientific Corp.
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Gaertner Scientific Corp.
Spencer Lens Co.

SPECTROPHOTOMETERS
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Bausch & Lomb Optical Co.
Gaertner Scientific Corp.

SPEED INDICATORS
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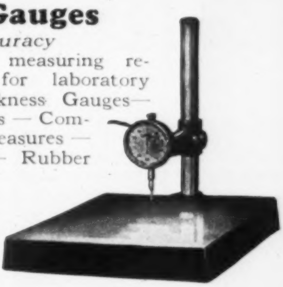

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A brief discussion.

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E. OWER, INSTRUMENTS, Vol. 3, No. 6, June 1930, pages 355-358, 1 fig.

Chapter V (Cont'd). This is the sixth installment of a series. It is a practical note on the use of pitot and static tubes.

MEASUREMENTS—INDUSTRIAL & SCIENTIFIC.

DR. WALTER BLOCK, INSTRUMENTS, Vol. 3, No. 6, June 1930, pages 359-368, 6 figs.

Chapter IV is devoted to the measurement of time. Chapter V to the measurement of angles.

THE ENGINEER'S HANDBOOK OF INDUSTRIAL INSTRUMENTS.

M. F. BEHAR, INSTRUMENTS, Vol. 3, No. 6, June 1930, pages 369-396, 24 figs.

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